OSPAR COMMISSION

Assessment of impacts of offshore oil and gas activities in the North-East Atlantic

Offshore Industry Series

2009

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998.
La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.

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Executive summary

The offshore oil and gas industry raises a wide range of environmental concerns

The offshore oil and gas industry is a significant industry within the OSPAR area, particularly in Regions II (Greater North Sea) and III (Celtic Seas), but increasingly so in Region I (Arctic Waters). There is a wide range of emissions and discharges associated with various offshore oil and gas activities, some of which require specific management measures. The key issues include oil and chemicals in produced water, impacts from historical cuttings piles and atmospheric emissions. Noise and light are also potentially of concern.

Offshore oil and gas activities can also physically disturb seabed habitats both during installation and decommissioning. The latter is a particular issue as many fields in the OSPAR region are near the end of their commercial lives.

Accidental events may also lead to the release of oil or chemicals to the environment.

OSPAR decisions and recommendations have focussed on reducing pollution

There have been seventeen OSPAR decisions and recommendations relating to the offshore oil and gas industry and a further seventeen agreements up to 2008. The vast majority of these have been made since 2000 with the aim of reducing the impacts of the industry on the marine environment.

OSPAR measures have achieved:

- a significant reduction in the use discharge of hazardous chemicals;
- the development of a Harmonised Mandatory Control System for the Use and Reduction of Discharge of Offshore Chemicals and a Harmonised Offshore Chemical Notification Format (HOCNF) which is a key element in OSPAR's control of offshore chemicals;
- a significant decrease in the volume of hydrocarbons discharged in produced water;
- a ban on the disposal of all but the most challenging installations offshore;
- a ban on the use and discharge of diesel based muds and cuttings;
- a ban on the discharge of untreated oil based muds and cuttings;
- a management regime for offshore cuttings piles;
- the implementation of environmental management systems offshore.

Changes in operational procedures have produced environmental benefits

Since the last QSR in 2000 there have been substantial changes in the way the offshore oil and gas industry operates in the OSPAR region. This has come about from the implementation of OSPAR measures by Contracting Parties and industry, including progressive emissions reductions.

There has been a measurable improvement in the quality of the marine environment

Implementing the OSPAR measures has reduced the areas affected by contaminated drill cuttings. Oil leaching rates from cuttings piles have also diminished. This has lessened consequent impacts to sediment dwelling fauna. Discharges of oil in produced water has been reduced by 21% from 2000 – 2006 on an overall OSPAR level. There are no results from monitoring to date that indicate biological effects from produced water in wild fish.

OSPAR will work towards further reduction of potential impacts.

Work will continue to move towards the target of the cessation of discharges, emissions and losses of hazardous substances. OSPAR also aims to achieve a reduction of oil in produced water by the year 2020, to a level which will adequately ensure that no harm accrues to the marine environment. Rather than focusing solely on oil in produced water, there is a recognised need for a more holistic approach to produced water management.

In addition, there may be specific issues relating to developing management measures for aging installations and infrastructure, in light of possible extended operating life. Another area where existing measures require critical evaluation is the Arctic part of Region I where there is a need for greater precaution.

Récapitulatif

L'industrie pétrolière et gazière d'offshore cause un large spectre de préoccupations pour l'environnement

L'industrie pétrolière et gazière d'offshore représente une industrie importante au sein de la zone OSPAR, en particulier dans les Régions II (mer du Nord au sens large) et III (mers celtiques), mais de plus en plus dans la Région I (eaux arctiques). Les diverses activités pétrolières et gazières d'offshore sont liées à un éventail important d'émissions et de rejets, certains nécessitant des mesures de gestion spécifiques. Les questions essentielles concernent notamment les hydrocarbures et les produits chimiques dans l'eau de production, les impacts des tas de déblais de forage historiques et les émissions atmosphériques. Le bruit et l'éclairage causent également des préoccupations potentielles.

Les activités pétrolières et gazières d'offshore peuvent également perturber physiquement les habitats du fond marin aussi bien au cours de l'installation que du démantèlement. Ce dernier constitue une question particulière car de nombreux champs de la région OSPAR approchent de la fin de leur vie commerciale.

Des incidents peuvent également contribuer au rejet d'hydrocarbures ou de produits chimiques dans l'environnement.

Les décisions et recommandations OSPAR se sont polarisées sur la réduction de la pollution

On compte dix-sept décisions et recommandations OSPAR portant sur l'industrie pétrolière et gazière d'offshore et dix-sept autres accords jusqu'en 2008. La plupart ont été convenus depuis 2000 afin de réduire les impacts de cette industrie sur le milieu marin.

Les mesures OSPAR ont permis:

- une réduction significative de l'utilisation des rejets de produits chimiques dangereux;
- le développement d'un système obligatoire et harmonisé de contrôle de l'utilisation des produits chimiques en offshore et de réduction de leurs rejets et d'un formulaire harmonisé de notification des produits chimiques d'offshore (HOCNF) qui représente un élément essentiel du contrôle des produits chimiques par OSPAR;
- une diminution significative du volume d'hydrocarbures rejetés dans l'eau de production;
- une interdiction de l'élimination de toutes les installations offshore à l'exception de celles présentant le plus de difficultés;
- une interdiction de l'utilisation et du rejet de boues et de déblais à base de diesel;
- une interdiction des rejets de boues à base d'huile et déblais non traités;
- un programme de gestion des tas de déblais de forage d'offshore;
- la mise en oeuvre de systèmes de gestion de l'environnement offshore.

Les modifications apportées aux procédures d'exploitation ont entraîné des avantages environnementaux

Le mode d'exploitation de l'industrie pétrolière et gazière d'offshore dans la zone OSPAR a subi des modifications importantes depuis le QSR 2000. Ceci résulte de la mise en œuvre, par les Parties contractantes et l'industrie, de mesures OSPAR, notamment les réductions progressives d'émissions.

La qualité du milieu marin présente une amélioration mesurable

La mise en oeuvre des mesures OSPAR a entraîné une réduction des zones affectées par les déblais de forage contaminés. La lixiviation d'hydrocarbures des tas de déblais a également diminué ce qui a réduit les impacts correspondants sur la faune vivant dans les sédiments. On a relevé une réduction de 21% des rejets d'hydrocarbures dans l'eau de production entre 2000 et 2006. A ce jour, les résultats de la surveillance n'indiquent aucun effet biologique de l'eau de production sur les stocks halieutiques sauvages.

OSPAR oeuvrera dans le sens d'une réduction plus importante des impacts potentiels

Les travaux continueront à progresser dans le sens de l'objectif de cessation des rejets, émissions et pertes de substances dangereuses. OSPAR a également pour objectif de parvenir à une réduction des hydrocarbures dans l'eau de production d'ici 2020, pour obtenir un niveau permettant de s'assurer de manière adéquate que le milieu marin n'est pas menacé. On reconnaît qu'il est nécessaire d'adopter une approche plus exhaustive pour la gestion de l'eau de production plutôt que de se focaliser uniquement sur les hydrocarbures dans l'eau de production.

De plus, des questions spécifiques peuvent se présenter, relatives au développement de mesures de gestion pour les installations et les infrastructures vieillissantes, à la lumière d'un prolongement de la durée de vie prévue. La partie arctique de la Région I, qui demande une précaution plus importante, représente une autre zone où des mesures appellent une évaluation critique.

1. Introduction

This report is part of a suite of assessments prepared under the OSPAR Joint Assessment and Monitoring Programme (JAMP) to evaluate impacts of human activities on the marine environment and contributes to the Quality Status Report 2010. It combines assessments of the extent, input and impact of offshore oil and gas activities (JAMP product OA-3), and of the impacts other than pollution from oil and gas activities (JAMP product BA-5).

Offshore oil and gas activities have developed in the OSPAR maritime area over the last 40 years. Overall, activities are still expanding and will remain a major economic feature in the future. The OSPAR Quality Status Report 2000 identified the oil and gas industry as the source of important pressures on the marine environment of the North-East Atlantic, including operational and accidental discharges of oil and polycyclic aromatic hydrocarbons and other hazardous substances as well as physical disturbance.

The purpose of this report is to evaluate the impacts of offshore oil and gas activities on the marine environment of the OSPAR maritime area and progress made since the Quality Status Report 2000 in addressing environmental concerns through international regulatory frameworks. Progress on reducing impacts and their effects on the quality of the marine environment is reported specifically since 1998 (the closing date for information taken into account in the Quality Status Report 2000) and, as far as relevant, in relation to the five Regions of the OSPAR maritime area.

The assessment is based on information from the annual OSPAR data reports on discharges, spills and emissions and assessments, information specifically reported by OSPAR countries in support of this assessment and external sources such as the Arctic Monitoring and Assessment Programme (AMAP).

Electronic navigator to complementary QSR assessments

- Environmental effects and releases of oil and chemicals from cuttings piles (update 2009) (OSPAR, 2007a)
- Environmental monitoring of impacts from offshore oil and gas activities (OSPAR, 2007b)
- Discharges, spills and emissions from offshore oil and gas installations in 2007 (OSPAR, 2009e)
- Discharges of radioactive substances from the non-nuclear sectors (OSPAR, 2009a)
- Environmental impact of underwater noise (OSPAR, 2009c)
- Environmental impact of shipping (OSPAR, 2009f)

2. What are the environmental issues?

Environmental impacts may arise at all stages of oil and gas activities, including initial exploration, production and final decommissioning. There is a broad range of environmental concerns including those relating to oil discharges from routine operations, the use and discharge of chemicals, accidental spills, drill cuttings, atmospheric emissions, low level naturally occurring radioactive material, noise, and to some extent the placement of installations and pipelines on the sea bed (Figure 2.1).

2.1 Extent and trends of oil and gas activities

The overall extent of oil and gas activities and the potential for future developments in the OSPAR Maritime Area are still increasing, but many factors control whether and when oil and gas development activities take place. They include economic factors such as long-term trends in oil and gas prices, international energy demand and energy security for developed countries. Other factors include the resource potential of areas, the geology of the deposit, the regulatory environment and infrastructure capacity.

Region II (Greater North Sea) has the highest levels of oil and gas exploration, appraisal and production, although production in mature fields is decreasing. Important oil and gas activities are also located in Region I (Arctic Waters) and Region III (Celtic Seas) and to a lesser degree in Region IV (Bay of Biscay and Iberian Coast). Oil and gas production in deep sea areas of Region V (Wider Atlantic) is still at an early stage. Numerous platforms in Region II will have to be decommissioned in the coming years as more and more matured oil and gas fields are becoming depleted and increasingly uneconomical. The more recent expansion of oil and gas activities into deeper water and northwards into the Arctic are some of today's environmental challenges. The total oil and gas production in the different OSPAR Regions is given in Table 2.1 and the distribution of offshore installations in Figure 2.2.

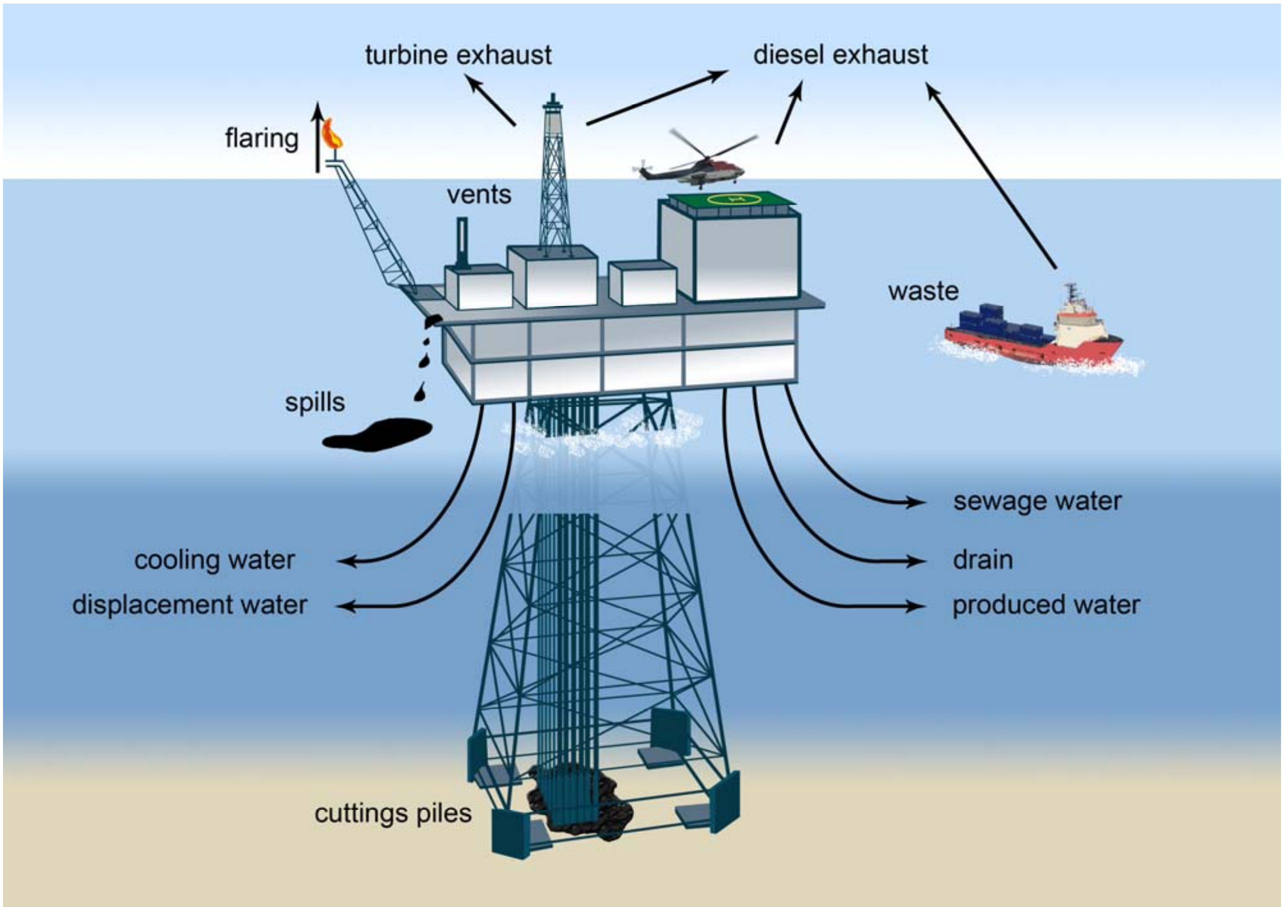

***Figure 2.1**: Sources of discharges and emissions from offshore installations.*

***Table 2.1:** The distribution of oil and gas production between the OSPAR regions in 2007. Figures are in tonnes of oil equivalents (toeq).*

OSPAR Regions	Oil production (toeq)	Gas production (toeq)
Region I: Arctic Waters	24 273 145	31 092 026
Region II: Greater North Sea	205 385 197	172 777 596
Region III: Celtic Seas	882 504	7 187 409
Region IV: Bay of Biscay and Iberian Coast	6628	none
Region V: Wider Atlantic	none	none
Total	230 547 474	211 057 031

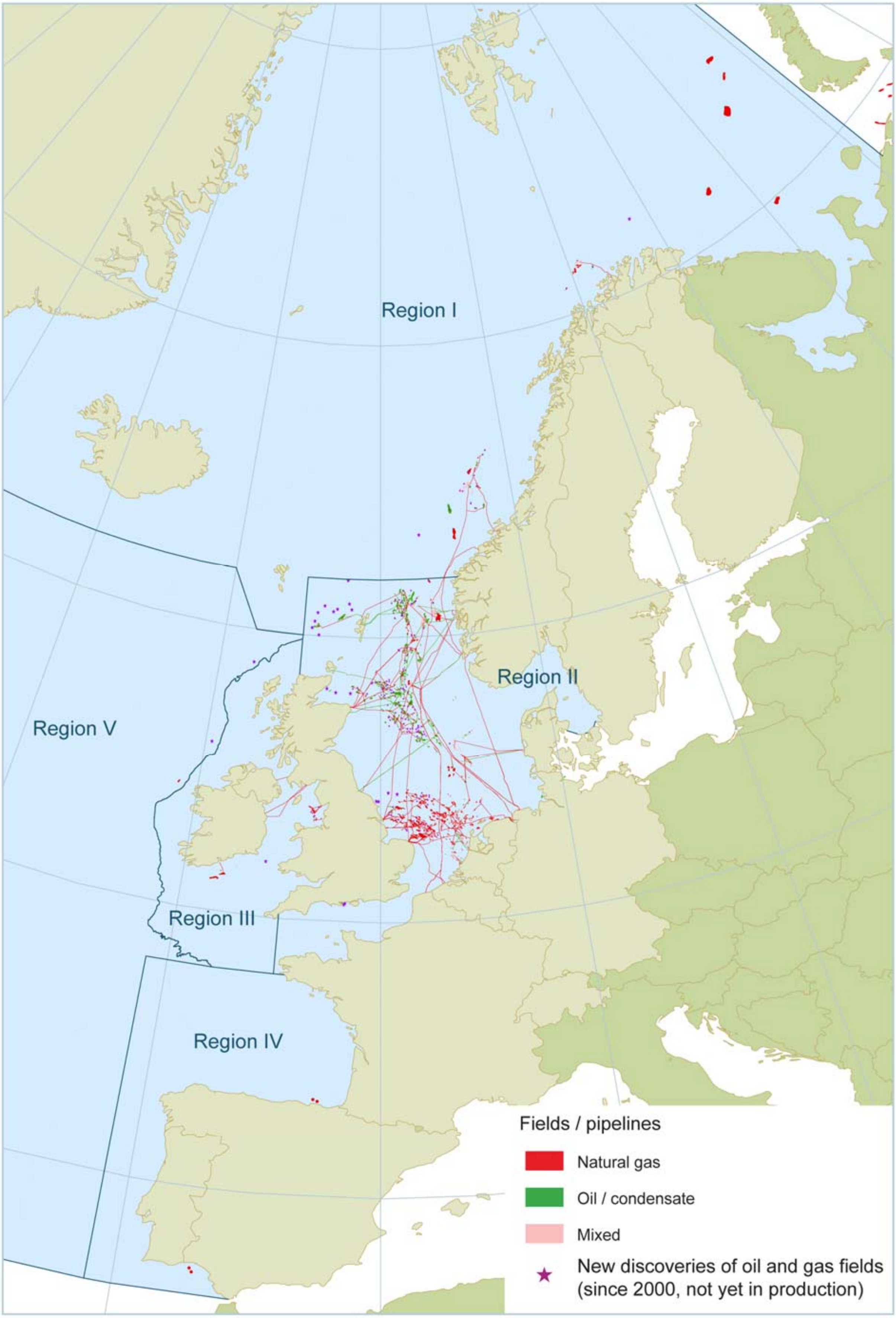

Figure 2.2a: *Offshore oil and gas installations and pipelines in the OSPAR Maritime Area in 2009. The whole OSPAR area. The pale blue lines show the border of each country's Exclusive Economic Zone. The grey area is the catchment area for the OSPAR Maritime Area.*

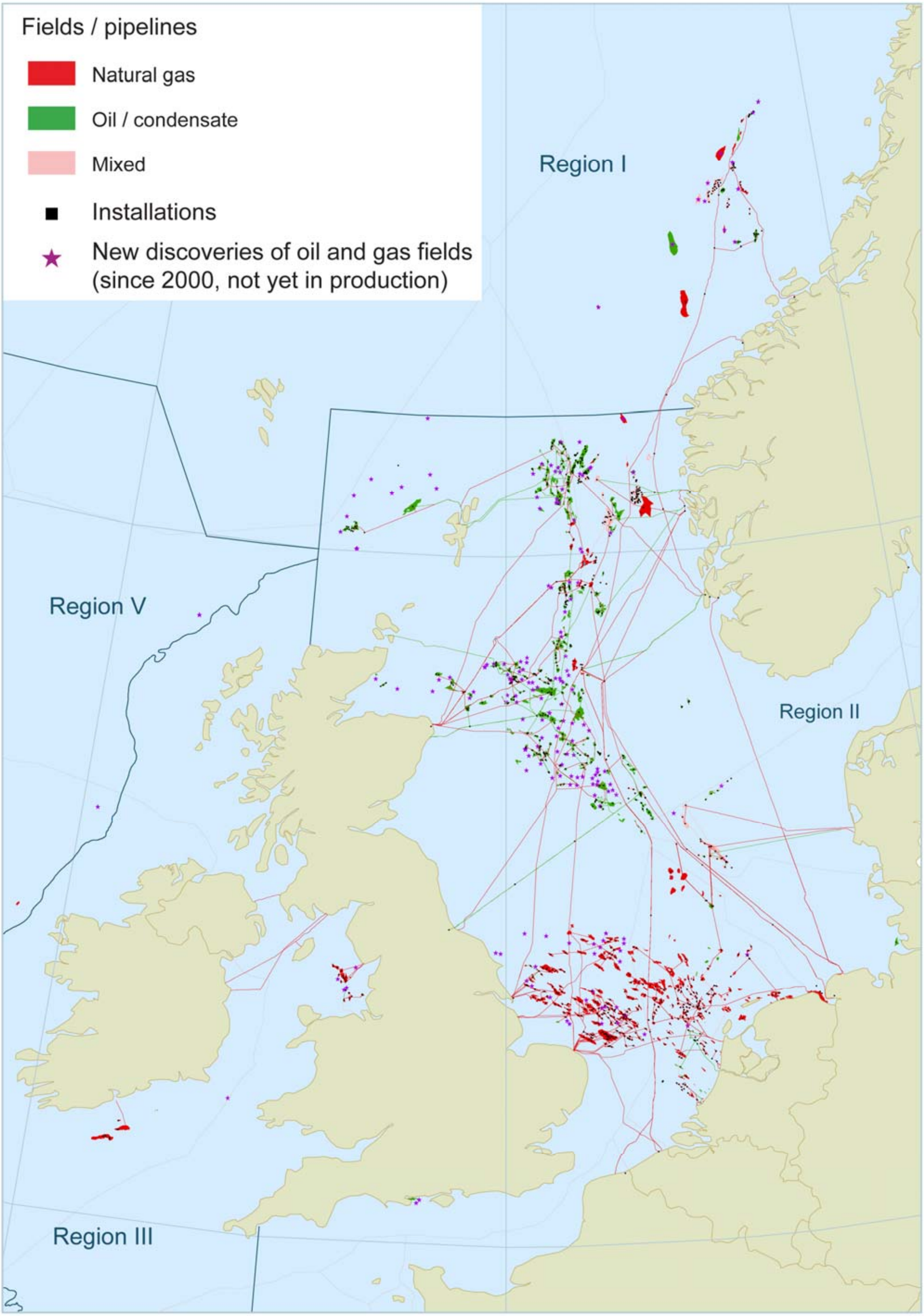

Figure 2.2b: *Offshore oil and gas installations and pipelines in the OSPAR Maritime Area in 2009. The areas where the main activities are taking place. The pale blue lines show the border of each country's Exclusive Economic Zone. The grey area is the catchment area for the OSPAR Maritime Area.*

2.1.1 Oil and gas activities will continue to expand into the Arctic

In Region I oil and gas are currently produced in the shallow waters of the Barents Sea and the Norwegian Sea. The Barents Sea is one of the widest shelf areas in the world with a mean depth of 230 m. Both Russia and Norway are exploiting the area which, from an ecological point of view, is considered to be very sensitive to oil and gas development. Region I also has areas with a unique bottom fauna of deep sea coldwater corals and sponges which are vulnerable and require many years to re-establish. The Norwegian and Barents Seas have a high biodiversity, high biological production and serve as important spawning and nursing areas for fish. Parts of the region also hold important numbers of breeding marine mammals and seabirds. In the Arctic, seasonal aggregations of animals, such as marine mammals in open water areas in sea ice, seabirds at breeding colonies, or fish at spawning time, may be particularly vulnerable, regardless of the size of a spill.

Oil based and synthetic based drilling fluids (Organic Phase Fluids or OPFs) were only discharged from a very few number of wells in the early years of exploration drilling in this region. Now only water based drilling fluids are discharged. However, the discharge of water based fluids and associated drill cuttings are still a concern in areas with sensitive benthic fauna, for example cold water corals.

In the longer-term also Iceland and possibly the Faroes may move from exploration to development and construction. It is predicted that offshore oil and gas activities will continue to expand into deeper waters and into more northerly, polar, regions. These areas will have more extreme climatic conditions and seasonal ice cover and there is a concern that this will cause an increase risk of accidental release of oil occurring, the consequences of which may be greater than elsewhere in the OSPAR region. In addition, it can be expected that difficulties to undertake remedial actions will be greater in a harsher environment (AMAP, 2007).

2.1.2 Most oil and gas activities take place in the Greater North Sea

Region II has more oil and gas development than any other OSPAR region with exploration and production occurring in Denmark, Germany, the Netherlands, Norway and United Kingdom. Exploration and production has been carried out in this region since the early 1960's and there are now 730 installations in the region. Overall, the North Sea is generally shallow with water depths rarely exceeding 100 m. The major oil developments have been in the northern part of the North Sea in the British and Norwegian sectors. Gas deposits are exploited mainly in the southern regions in the British, Dutch and Danish sectors, as well as in Norwegian waters. There are several gas and oil production platforms in the Wadden Sea (for example Germany). The seabed of the southern North Sea comprises largely sandy sediments and has relatively strong tidal currents thus the fauna is adapted to changing conditions and the movement of sand along the bottom. In the more northerly areas of the North Sea the sediments are less sandy and less mobile with weaker currents where there are, in places, significant areas of corals and sponges.

As Region II has the longest history of oil and gas development and the most mature oil and gas fields, many of the activities that caused impacts during the earlier years of development up until the 1980's have since ceased and the main concerns now relate to impacts from historical cuttings piles and the discharge of produced water.

2.1.3 Important oil and gas activities occur in Region III, mainly in the Irish Sea

Exploration drilling in Region III has been undertaken in the Celtic Seas since 1969 with oil production starting in 1985. The region where most oil and gas development occurs is dominated by relatively shallow bays in three separated sea areas (Celtic, Irish and Malin seas). Most of the production facilities and pipelines are situated in the Irish Sea in particular around Liverpool and Morecambe Bays off the English coast. There have also been recent developments occurring off Cork in the Celtic sea. The main areas of concern arise from the risk of an oil spill in near shore areas occurring in areas of high seabird numbers, particularly during the winter period.

2.1.4 Only minor oil and gas activities take place in Region IV (Bay of Biscay and Iberian Coast)

Region IV has potential for oil exploitation on the sedimentary basins in the inner south-eastern part of the Bay of Biscay. The coastal plains of Aquitaine (France) and the Northern coast of Spain have been exploited and Spain operates some installations on their shelf. There is also gas production in the Gulf of Cadiz with pipeline to the shore.

2.1.5 Oil and gas production in the Wider Atlantic (Region V) is still at an early stage but developing

Exploration and development within Region V, the wider Atlantic, is still at an early stage. However there are developments being considered to the west of the Hebrides and Rockall in water depths of greater than 2000 m. The seabed in these areas comprise largely of muds and clays with areas containing cold water corals. Some parts of the region are important for seabirds and marine mammals.

2.2 Pressures on the marine environment from oil and gas activities

The main pressures on the marine environment from oil and gas activities include operational and accidental discharges of chemicals, crude oil and produced water containing substances such as oil components, polycyclic aromatic hydrocarbons, alkyl phenols and heavy metals. In addition there could be concerns related to atmospheric emissions, low level naturally occurring radioactive material, noise, and the placement of installations and pipelines on the seabed.

2.2.1 Oil

Oil is released from a variety of sources during exploration and production activities. Most oil entering the marine environmental from such activities is in produced water (see below), but deck and machinery space drainage may also contain small quantities of oil. Dropout of oil when flaring during well testing and well work-overs is another potential source of oil from offshore activities, but is generally considered insignificant. Another potential source of oil is accidental release during drilling, the operation of offshore installations and from shipping. Shipping associated with offshore oil and gas activities is not included in this assessment (OSPAR, 2009f).

Box 1

Ecological implications of oil in the marine environment

Oil does not affect all components of marine ecosystems equally; some are more vulnerable to physical impacts, others to chemical toxicity and some are relatively resilient to both. The key effects of oil include the following:

- Oil in large quantities may coat the feathers of seabirds and fur of some marine mammals. This reduces their ability to provide buoyancy and insulation, leading to increased mortality.
- Mammals and turtles may ingest oil with food and thereby be exposed to potential toxic effects. When preening oiled feathers, birds may also ingest oil with attendant toxic effects. There is evidence to suggest that some tissue hydrocarbons may reduce breeding success in birds and mammals.
- Fish eggs and larvae are more susceptible to toxic effects of oil than are adults. Adult fish may accumulate hydrocarbons in their tissues that may affect their health and also taint their flesh. Toxic components in crude oil include Polycyclic Aromatic Hydrocarbons (PAHs), phenols, naphthalene, phenanthrene and pyrenes. PAHs can also be mutagenic and carcinogenic.
- Invertebrates vary greatly in their sensitivity to oil. Corals are among the most sensitive, whereas some barnacles and limpets may withstand a degree of oiling. As with finfish, shellfish may accumulate oil residues with attendant secondary effects, particularly relating to health.
- Though individual planktonic organisms can experience toxic effects from oil in water, the very high turnover of plankton populations means that the plankton is relatively unaffected by oil.
- Oil does not always stick to seaweeds because of their mucilaginous coating, but cultured algae can become tainted and lose their commercial value. Vascular plants such as seagrasses may be affected, and the species balance of communities exposed to oil or oil residues in water may shift from perennial species to more rapidly growing annual ones.

2.2.2 Chemicals

The main discharges of chemicals arise from drilling activities and discharges of chemicals in produced water. The use of chemicals is critical for the production of oil and gas. The main use of chemicals is for drilling and production operations and includes:

- rig and turbine washes;
- pipe dopes used to lubricate drill pipe joints;
- hydraulic fluids used to control wellheads, blow-out preventers and subsea valves;
- chemicals used in the actual production and processing of hydrocarbons;
- water-based and organic phase drilling fluids;
- cementing chemicals;
- work-over chemicals;
- stimulation chemicals;
- completion chemicals;
- water injection chemicals;
- water and gas tracers;
- chemicals used in “closed systems” where periodic refill is required;
- jacking grease.

Chemicals are also used to maintain pipelines and ensure pipeline integrity; these include biocides and oxygen scavengers.

Unwanted effects from chemicals discharged into the marine environment can include acute or long term toxic effect to marine organisms. Among the long term effects especially hormone interfering, mutagenic and reprotoxic effects give rise to concern. Persistent and bioaccumulative chemicals can magnify in the food chain and result in high exposure levels for top predators like seabirds and marine mammals and for human seafood consumers. Low concentrations of some substances are sufficient to interfere with the hormone and immune system and reproduction processes. Biological effects can extend beyond individual marine organisms to a whole population with adverse consequences for species composition and ecosystem structures.

Offshore chemicals are also of major concern for the working environment on offshore installations; some chemicals may cause allergy, skin irritation or more serious effects such as cancer.

2.2.3 Radioactive substances

Data on low level radioactive discharges from non-nuclear sources, including the oil and gas industry, are collated annually by OSPAR. The main source of discharge is associated with produced water. Other sources are descaling operations and use of radioactive tracers. It has been calculated that 7.4 Tbq of alpha activity and 4.9 Tbq of beta activity were discharged in 2007 (OSPAR, 2009a).

2.2.4 Produced water

Produced water is the water found in reservoirs along with the oil or gas. When the oil or gas is extracted, produced water is associated with it. Entrained within the water there are hydrocarbons that are, as far as possible, removed from the water prior to any discharge. As the volume of hydrocarbons found in a reservoir decreases over the life of the field the volume of produced water generally increases. Consequently, most produced water is from the older, more developed fields of the North Sea. Produced water is usually either discharged into the sea or injected back into the reservoir from where it originated (Figure 2.3).

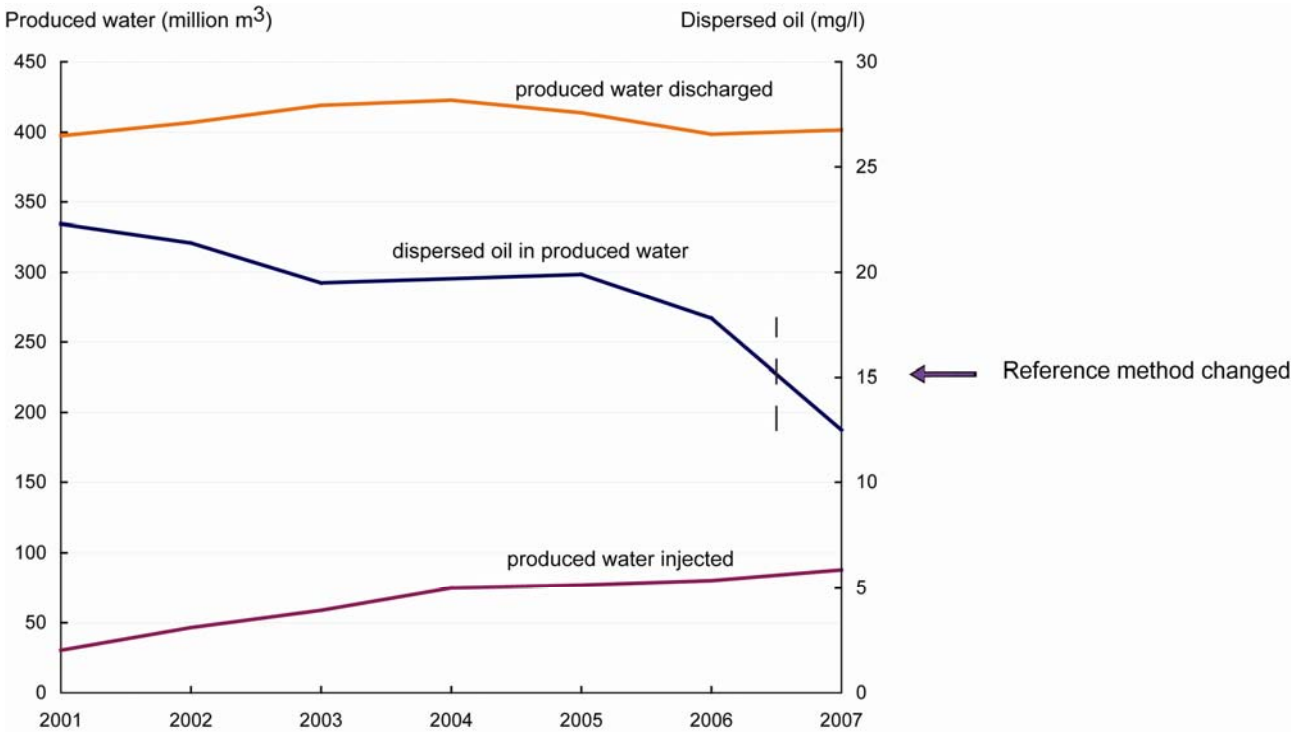

Figure 2.3: *Trends in the amounts of produced water discharged and injected, and the quality of the produced water (oil content).*

Produced water also contains low concentrations of hazardous substances[1] that occur naturally in the reservoir, such as heavy metals, aromatic hydrocarbons, alkyl phenols and radioactive substances.

An OSPAR survey analysing produced water samples from 36 oil and gas fields in the North Sea in 2008 indicated that the concentrations of heavy metals in produced water are very low. Produced water volumes from gas installations are low compared to volumes from oil producing installations, but may contain higher concentrations of lead. Concentrations of heavy metals within produced water from oil producing platforms are generally low and close to background concentrations. Produced water will also contain residues of chemicals used to assist drilling, well maintenance and oil and gas separation.

2.2.5 Cuttings piles

Cuttings piles arise from drilling operations where the drilled cuttings and associated drilling fluids are discharged at the location of the well. From a sample of 98 wells drilled in the United Kingdom the average volume of cuttings per well was 1481 tonnes and the average volume of cuttings from 33 locations where multiple wells had been drilled was 367 m^3 per well. Cuttings can build up into piles around the platforms in areas where currents are generally weak.

Cuttings may contain traces of the drilling fluids used in the wells from which they are derived. Drilling fluids are categorised into either water-based or organic-phase fluids[2]. Old cuttings piles may contain organic-phase drilling fluids and have been identified as possible sources of hydrocarbon releases into the marine environment, due to remobilisation of residues of oil still found in the piles and natural leaching in to the

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[1] Hazardous substances are natural and synthetic substances with PBT (persistent, bioaccumulative and toxic) properties or of equivalent level of concern. See full definition for the purposes of OSPAR in Appendix 2 to the Strategies of the OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic, Agreement 2003/21.

[2] Organic-phase drilling fluids (OPFs) are emulsions of water and other additives in which the continuous phase is a water-immiscible organic fluid of animal, vegetable or mineral origin. Two groups of OPFs are recognised: Oil-based fluids use paraffinic or lower aromatic mineral oils, whereas synthetic fluids use highly refined mineral, animal or vegetable derived oils. Further definitions of OPF can be found in section 8, Glossary.

water column. Due to low rates of leaching, this is not considered a significant pressure. However, there have been concerns raised over the potential for oil and other contaminants to be released into the marine environment from the remobilisation of cuttings piles due to disturbance from other activities, *i.e.* trawling and decommissioning activities, and OSPAR is addressing the issue.

With OSPAR Decision 2000/3 on the Use of Organic-Phase Drilling Fluids (OPF) and the Discharge of OPF-contaminated Cuttings entering into force, discharges of organic-phase drilling fluids has not been reported since 2004 (see Figure 4.1). Consequently the remobilisation of old cuttings piles and accidental discharges are now the main potential sources of OPF-contaminated cuttings.

As discharge of OPFs has largely ceased, water based drilling fluids are now the only drilling fluids released into the marine environment. The main constituents in such fluids are weighting materials such as ilmenite, bentonite and barite. Both cuttings and weighting materials may contain traces of heavy metals, however, these trace contaminants are not considered to be bioavailable.

2.2.6 Installations and pipelines

In 2007 there were 1281operational oil and gas offshore installations in the OSPAR maritime area, of which 730 released substances to the sea or the air (Figure 2.4).

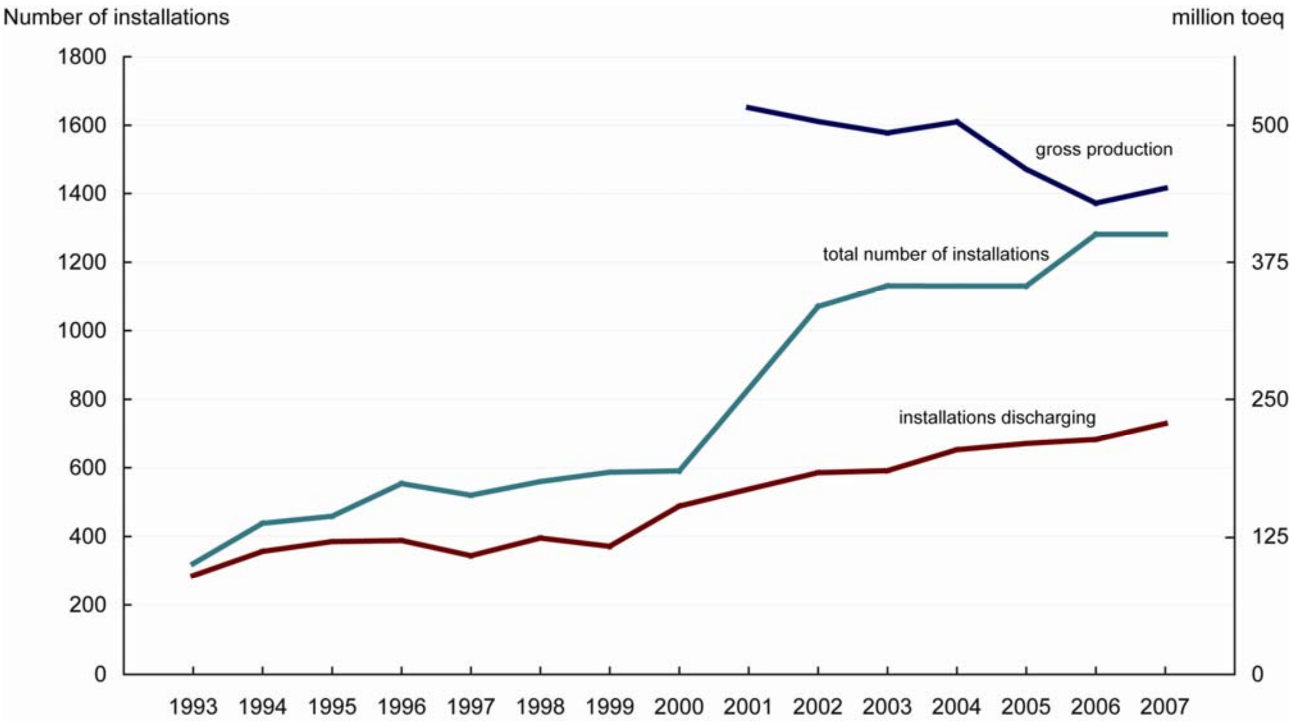


Figure 2.4: *Developments in the number of offshore installations and installations discharging.*

In the United Kingdom sector over 34 000 km of oil and gas related pipelines have been laid, of which 7718 km are considered to be major trunk pipelines carrying either oil or gas. The majority of pipelines in the United Kingdom are inter-field lines transporting hydrocarbons from one field to a platform at another field where the hydrocarbons are usually processed and transferred to a trunk pipeline. In the Norwegian sector the total length of pipelines is estimated to be approximately 12 170 km, with about 50% being used to transport gas.

The footprint of the pipeline is dependent on the length, diameter and whether or not it is trenched. The seabed currents and the type of sediment will effect the accumulation and scouring of the sediment around the pipeline and, if trenched, the frequency of the appearance of spans (*i.e*. areas where the pipe emerges from the trench). The accumulation and scouring of sediment and the appearance of spans is dependent on local and pipeline specific conditions. Assuming that a 10 m wide corridor along the pipeline may potentially be affected by pipe laying operations, then approximately 340 km^2 in the United Kingdom sector and 120 km^2 in the Norwegian sector are impacted by oil and gas related pipelines. It can be assumed for the majority of pipelines that once a pipeline is laid, the impact on the environment does not extend beyond the area directly beneath the pipeline itself. For those that are buried the impact is less.

In addition to the pipelines, the large number of installations will also cause a physical impact on the seabed, but due to the large variety of dimensions of the different installations, the total area affected is not known. Parallel to the pipelines, it can be assumed that only the area directly beneath the installation is affected by the physical presence of platforms and similar structures. Due to the number and length of pipelines placed on or under the seabed the overall physical impact of pipelines is considered greater than those from the other installations or operations mentioned above.

2.2.7 Accidental discharges

Accidental discharges of oil and chemicals can arise from a number of different sources, including equipment failure, or human errors during offloading and filling of tanks, clean up operations and drainage of sea sumps. There are concerns that the ageing of infrastructure may increase the risk of accidents resulting in spills of oil and chemicals, as might be the case in Region II. Since 2000 there has been a greater awareness by industry for the need to report all spills irrespective of the spill size. This may be due to better regulatory controls and increased environmental awareness.

2.2.8 Air pollution

The offshore oil and gas industry requires substantial power in order to extract, process and export hydrocarbons consequently the main source of emissions are from power generation. Flaring of hydrocarbons is also required during well testing and well clean-up operations and to ensure safety at the platform. These are the main sources of the majority of the atmospheric emissions. Tanker loading and off-loading also contribute to emissions, particularly volatile organic compounds (VOCs).

2.2.9 Light

There are concerns over the potential impacts on birds from flaring and lighting from offshore structures. A study undertaken in the Southern North Sea by the Netherlands has suggested that the chance that flaring directly impacts a flock of birds is small and only significant during the migration periods. However, the study estimates that about 10% of the total bird population crossing the North Sea is impacted in some way by light emitted from offshore installations (TNO, 2006). An assessment of the scale of impact in United Kingdom waters concluded that under certain weather conditions large numbers of birds can occasionally be attracted to offshore platforms. However, relatively few species were attracted in sizable numbers and those that were had large and stable breeding populations thus indicating that no significant environmental impact was occurring.

2.2.10 Noise

Noise arising from activities related to the offshore oil and gas industry includes elements such as construction work, drilling, ships traffic and seismic surveys and is addressed within the OSPAR JAMP assessment and background document on noise (OSPAR, 2009b and c)

3. What has been done?

The OSPAR Commission has put in place a significant number of measures aimed at reducing emissions and discharges from the oil and gas industry within the OSPAR region. As of 2009 there are 17 OSPAR Decisions and Recommendations relating to the offshore oil and gas industry and further 18 other agreements. The vast majority of these have been made since 2000 and aim to reduce the environmental impacts of the industry on the marine environment. Measures introduced by OSPAR have reduced oil in produced water discharges and the use and discharge of chemicals and drilling fluids. OSPAR has, with a few exceptions, effectively prohibited the disposal of disused offshore installations at sea and has introduced the need for industry to have effective environmental management systems.

3.1 Oil in produced water

In order to reduce discharges of oil in produced water, the OSPAR Recommendation 2001/1 for the Management of Produced Water from Offshore Installations defined a performance standard of 40 mg dispersed oil per litre of produced water. This limit was later reduced to 30 mg of dispersed oil per litre of produced water with effect from 2007. Furthermore, Contracting Parties agreed that by 2006 they should have achieved a minimum of 15% reduction in the total quantity of oil in produced water discharged into the sea compared to the year 2000.

3.2 Drilling fluids

The use of diesel-oil based drilling fluids was prohibited by OSPAR from 1 January 1987 and the discharge of untreated cuttings contaminated with oil-based drilling fluids ceased following PARCOM Decision 92/2 on the use of oil-based muds. Following OSPAR Decision 2000/3 on the use of organic-phase drilling fluids, the use and discharge of OPFs were further restricted and now require prior authorisation by the competent national authority. The discharge into the sea of whole OPFs and of cuttings contaminated with oil-based drilling fluids at a concentration greater than 1% by weight on dry cuttings has been prohibited since 2001. Cuttings contaminated with synthetic fluids can only be discharged in exceptional and very rare circumstances of *force majeure.*

The use of oil-based fluids is not prohibited as it is required in lower sections of most wells. Prior to any usage national authorisation is required. Drill cuttings contaminated with oil-based fluids are either injected into subsurface formations or transported to shore where they are treated.

The OSPAR Decision 2000/3 allows the discharge of cuttings with oil concentrations below 1%. New technologies have now been developed and are used that clean the cuttings down to concentrations below this limit.

3.3 Cuttings piles

Based on guidance contained in OSPAR Recommendation 2006/5 on Management Regime for Offshore Cuttings, Contracting Parties have undertaken screening assessments at specific locations. These assessments aimed to determine whether, for any of the relevant cuttings piles, the rate of oil loss to the water column was greater than 10 tonnes per year or whether the area of persistently contaminated seabed was greater than 500 km^2 per year. The assessments indicated that immediate action was not required to reduce the environmental impact of any piles and that their management could be addressed as part of the decommissioning plan for the installation (OSPAR, 2009d).

The United Kingdom and Norway assessed the potential for impacts arising from the re-distribution of contaminated cuttings due to disturbance. The report produced by Norway (DNV, 2006a) assessing the level of hydrocarbon loss due to dredging activities concluded that leaching from dredging (water phase hydrocarbons) and leaching from a pile left undisturbed are small compared to the potential loss due to particle bound hydrocarbon losses during a dredging operation. However, the authors warn that the estimates presented within the report must be treated with care and be regarded as indications only.

The studies undertaken in the United Kingdom (OSPAR, 2007a) using trawling operations to disturb a cuttings pile concluded that although contamination was spread, it was not in amounts or at rates likely to pose serious wider contamination or toxicological threats to the marine environment. The act of spreading will encourage, albeit at a slow rate, increased aeration of deposited material which will enable its further degradation by natural processes.

Further studies undertaken in the United Kingdom (OSPAR, 2007a) looked at the possible impacts from the removal of contaminated cuttings piles using suction devices. Results from these studies indicated that plume generation and drifting of re-suspended material was low during removal operations. Levels of oil contamination on the disturbed cuttings were found to be similar to those expected on undisturbed piles. It was concluded that the majority of oil remains bound onto cuttings during these operations and that the low level of oil in the water associated with the solid material was possibly due to the high ratio of water recovered with the solids. The trial indicated that the disturbance of cuttings piles by suction equipment results in relatively low secondary pollution with the oil generally remaining bound to the drill cuttings. Little secondary pollution was discernable at a distance of 100 m from the removal operations and no effects were seen at the sea surface.

Guidance documents have been developed in order to consistently and accurately monitor the impacts arising from offshore oil and gas activities. Work on this guidance started in the early 1990’s and the OSPAR Guidelines for Monitoring the Environmental Impact of Offshore Oil and Gas Activities were first agreed on in 2001 and revised in 2004 (Agreement 2004-11).

3.4 Chemical use and discharge

In 1996, OSPAR’s predecessor, PARCOM, adopted Decision 1996/3 on a Harmonised Mandatory Control System for the Use and Reduction of Discharge of Offshore Chemicals (HMCS). Following a trial period, its effectiveness was reviewed and a package of new OSPAR measures were established and adopted in 2000 (OSPAR Decision 2000/2 on a Harmonised Mandatory Control System for the Use and Reduction of the Discharge of Offshore Chemicals, as amended). The HMCS Decision, along with OSPAR Recommendation 2000/4 on a Harmonised Pre-Screening Scheme for Offshore Chemicals (as amended) and OSPAR Recommendation 2000/5 on a Harmonised Offshore Chemical Notification Format (HOCNF) (as amended) is a key element in OSPAR’s control of offshore chemicals. It sets out, *inter alia*, what kind of data and information must be notified for to the competent national authorities of the Contracting Parties. For each chemical, it provides advice that is to be taken into account by the authorities with the aim of harmonising authorisation and permitting procedures for chemicals amongst the Contracting Parties. The measures also include more detailed guidance on the substitution and ranking of chemicals.

3.5 Physical impact

Over the years there has been an improvement in the technology involved in the placement of infrastructure on the seabed and greater awareness of the potential environmental impacts that these may cause. For example, the extensive use of Remotely Operated Vehicles (ROVs) and better navigational equipment makes it easier to find the best transects and avoid the disturbance of vulnerable marine communities.

Assessment of the direct physical impact the placing of a structure has on a seabed is addressed within the relevant environmental statement and associated environmental impact assessment. Environmental monitoring of the physical impacts arising by the placing a structure on the seabed is undertaken on a case by case basis depending on the particular sensitivities associated in the area. The monitoring of pipelines is routinely undertaken by developers to ensure that the integrity of the pipeline is being maintained. The results from such surveys can also be used to provide useful information on the physical impact that the laying of the line has had.

3.6 Atmospheric emissions

OSPAR does not specifically regulate atmospheric emissions from the oil and gas industry. However, there are a number of relevant EU Directives and international conventions which apply to OSPAR Contracting Parties. Since 2000 there has been a significant change in the way atmospheric emissions are managed with the development and implementation of the European Union Emissions Trading Scheme (EU-ETS), the EU Directive on integrated pollution prevention and control (IPPC) (2008/1/EC), the EU Directive on national emission ceilings for certain atmospheric pollutants (2001/81) and the UN Economic Commission for Europe’s (UN-ECE) Convention on Long-Range Transport of Air Pollution.

3.7 Decommissioning

As one of the main outcomes of the 1998 OSPAR Ministerial Meeting in Sintra, Portugal, the dumping, and leaving wholly or partly in place, of disused offshore installations is prohibited within the maritime area (OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations). Only for certain categories and subject to an assessment, the competent authority of the relevant Contracting Party may give permission to leave installations or parts of installations in place (for example for steel installations weighing more than ten thousand tonnes in air or gravity based concrete installations).

OSPAR monitors the development of offshore installations and maintains an updated inventory of all oil and gas offshore installations in the OSPAR maritime area, the OSPAR Oil and Gas Offshore inventory. The database includes the name and ID number, location, operator, water depth, production start, current status, category and function of the installations.

4. Did it work?

Based on reported data from Contracting Parties, it is possible to follow trends in inputs from the oil and gas industry. Ongoing monitoring in the marine environment also assists in assessing whether the actions taken have resulted in a measurable reduction in the impacts to the marine environment.

4.1 Produced water

Although the volume of produced water generated has increased with the increasing age of the fields, the amount of produced water discharged has remained reasonably constant since 2000 as more produced water is injected into sub-surface formations (Figure 2.3). The injection and the considerable efforts and investments of Contracting Parties and industry to optimise processes and introduce new water treatment technology resulted in a decrease of 21% of the total amount of dispersed oil discharged with produced water between 2000 and 2006 on an overall OSPAR level. The OSPAR target of 15% reduction in the total quantity of oil in produced water discharged by each country (as in OSPAR Recommendation 2001/1) has been met by most OSPAR countries. The amount of oil in produced water discharged from offshore installations in the OSPAR area reached a peak in 1997 with most produced water discharged in Region II (Figure 4.1).

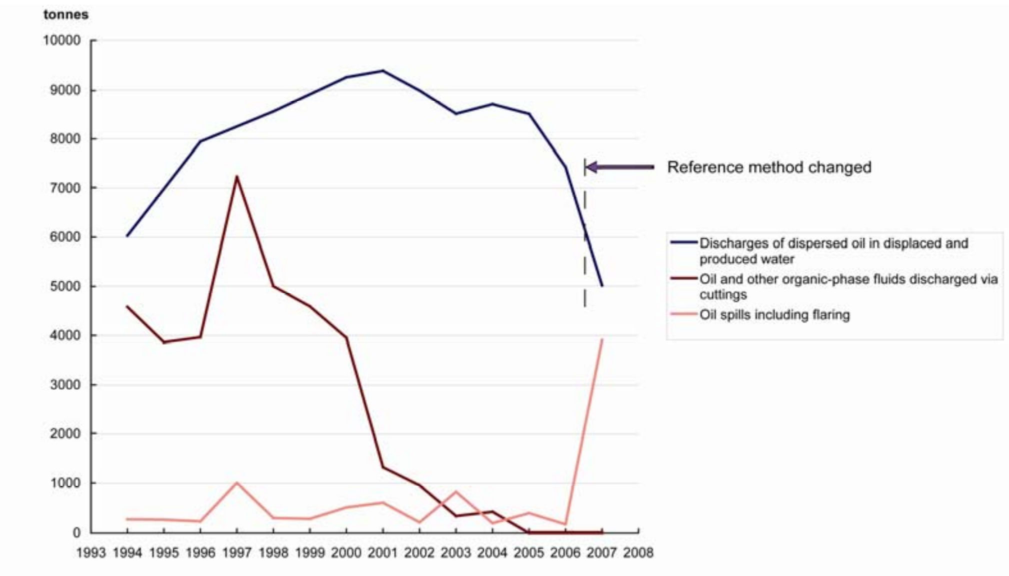


Figure 4.1: *Trends in discharges from the different sources of oil. From 2007 a new OSPAR reference method for the analysis of dispersed oil in produced water was implemented. This partly explains the reduction between 2006 and 2007 in discharges of oil in produced water. A single large oil spill in Norway in 2007 accounts for the steep increase in oil spills compared to previous years.*

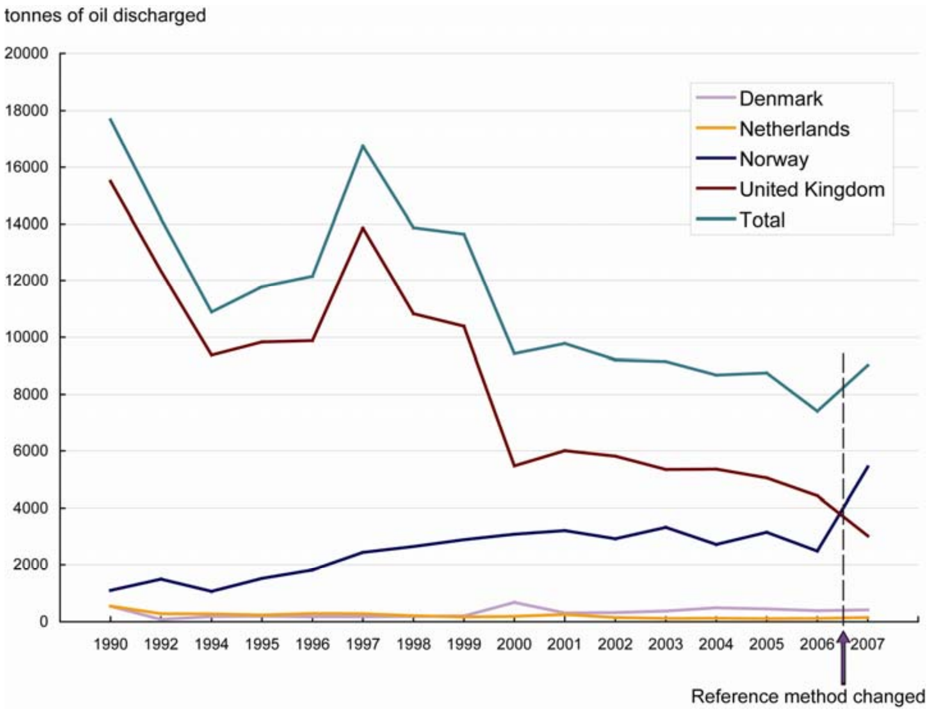


Figure 4.2: *Discharges and spillages of dispersed oil (tonnes) per country and total, 1990 – 2007.*

According to the OSPAR report on Discharges, Spills and Emissions from Offshore Oil and Gas Installations in 2007 (OSPAR, 2009e), all but 22 installations achieved the performance standard of maximum 30 mg/l dispersed oil in produced water as required by OSPAR Recommendation 2001/1 on produced water. This is a significant reduction in number of installations from reporting began in 1994 (59 installations).

4.2 Oil spills

Since 2000 there has been an overall decrease in the number of oil spills, but the total volume of spills across the OSPAR region varies from year to year, see Figure 4.1 and Table 2.2. Over 95% of all spills are less than one tonne and a single larger spill can make a substantial difference in the annual total of oil spilled. The total for 2007 is dominated by a single large oil spill off Norway in which the total volume of oil spilled was almost as big as the total amount discharged in produced and displacement water for the whole OSPAR area in 2007.

Table 2.2: *Oil spills in the Convention area 2000-2007, number and total quantities in tonnes of oil.*

Year:	2000	2001	2002	2003	2004	2005	2006	2007
Spills >1 tonne:								
Number	22	25	27	19	24	17	15	22
Quantity	454	537	158	744	157	345	135	3882
Spills ≤1 tonne:								
Number	700	743	774	602	654	638	494	493
Quantity	60	68	56	80	42	54	38	25
Total:								
Number	722	768	801	621	678	655	509	515
Quantity	514	605	214	824	199	399	173	3907*

* Total dominated by a single large oil spill at the Statfjord field, Norwegian continental shelf, OSPAR Region II.

4.3 Drilling fluids

The discharge of diesel-oil based drilling fluids up until 1987 and oil-based fluids up until 1996 led to high concentrations of hydrocarbons in the sediments in the vicinity of the wells. Surveys undertaken at the time indicated a rising trend in sediment hydrocarbon concentrations above background levels (BERR, 2008).

The discharge of oil-based drilling fluids ceased in 1996 and no OPFs discharges have been reported since 2004 (Figure 4.1). Consequently, the aim of Decision 2000/3 on the Use of Organic-Phase Drilling Fluids (OPF) and the Discharge of OPF-contaminated Cuttings is now fulfilled, and no further work is required.

Injection of contaminated drill cuttings is widespread and has no impact on the seabed or water column. There has been one occasion, in the Norwegian sector, where there was a breakthrough of oil contaminated cuttings to the seabed, and between 3000 and 5000 m^3 of drill cuttings surfaced on the seafloor.

The effects of stopping any deliberate discharge of oil-based and synthetic drilling fluids and untreated cuttings contaminated with such fluids into the marine environment have been monitored to determine whether this has led to an improvement of environmental conditions around offshore installations. Evidence from Denmark, Netherlands, Norway and the United Kingdom all indicate a reduction in the total hydrocarbon concentrations (THC) in sediments and the recovery of the associated benthic communities.

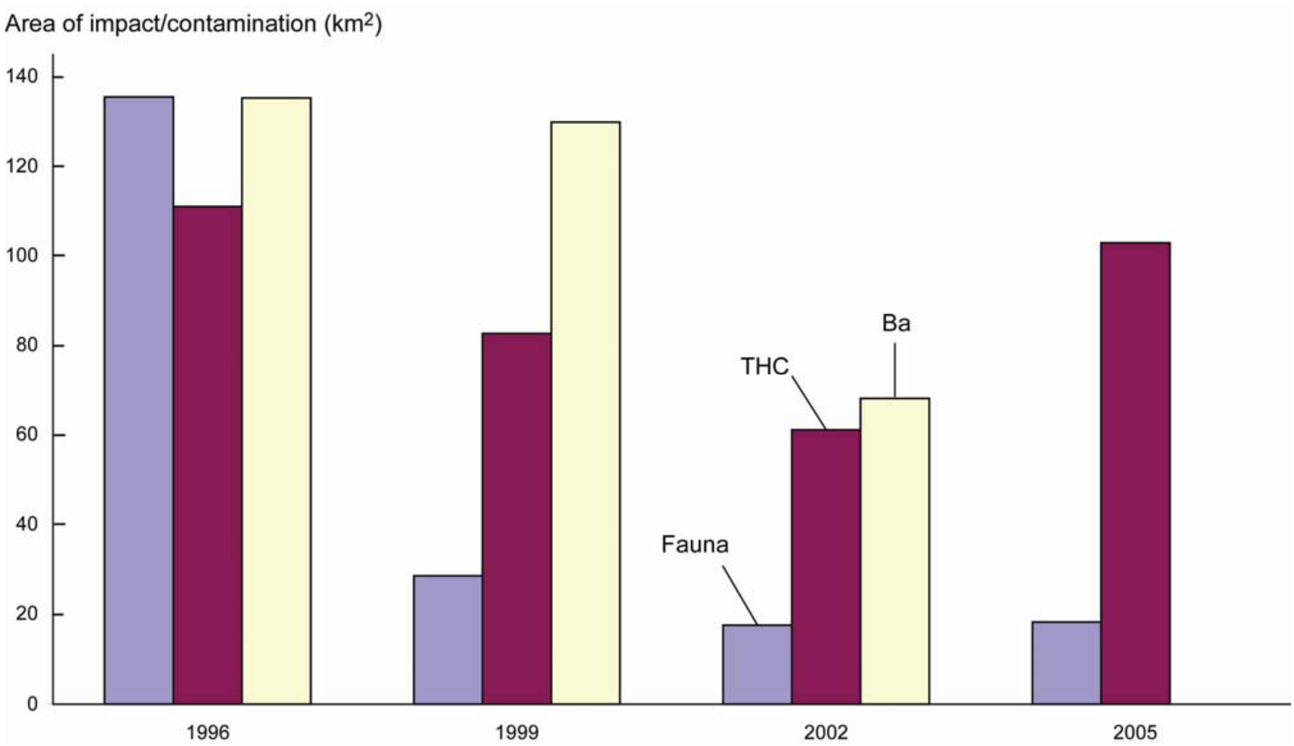
The monitoring undertaken in the Danish sector indicates that the impact and recovery of benthic communities is mostly related to the spatial and temporal changes in the THC concentrations and to a lesser extent to Barium concentrations in the sediments around the platforms. The concentrations of PAH and heavy metals other than barium are presently so low that further analysis is not considered necessary (Møhlenberg *et al.,* 2008).

Studies undertaken by Norway indicate that in some cases the impacts from the discharge of drilling fluids were severe. In some areas however, levels of potential contaminants and areas of impact have significantly decreased since the cessation of discharges. This continues the initial trend noted in earlier reports. Evidence from case studies suggests that this is probably due to the change from the discharge of oil-based to water-based fluids. The Norwegian studies also identified that there was no evidence of any change in area of impact or level of contamination in some areas. In some cases there has been an increase in the level of contamination although there was little evidence at the regional level that this was due to changes in discharges (Renaud *et al.*, 2008).

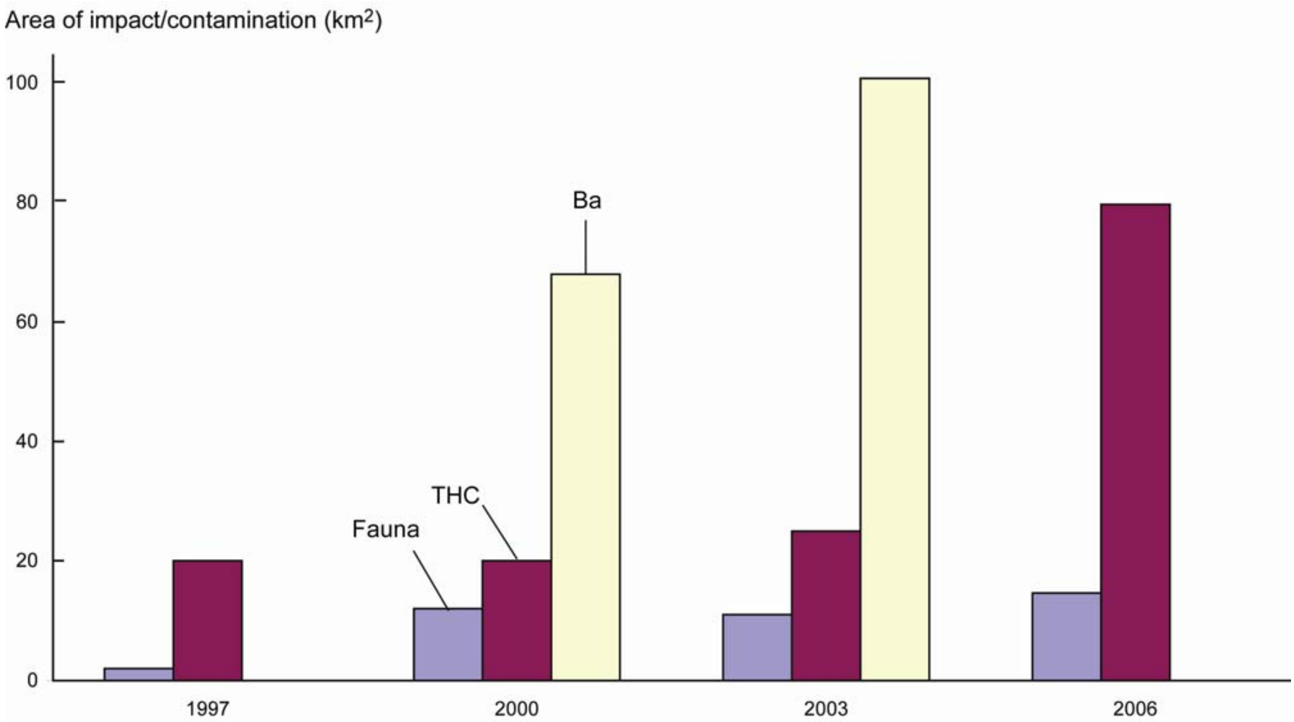
In Figure 4.3 a and b the overall trends in three different parameters are shown from two monitoring regions in the Norwegian sector. This is supported by the case study in the Annex showing results from more than 20 years of monitoring of different parameters in sediments at Ekofisk.

The Ekofisk region (monitoring region A) is a mature area with a decreasing trend in area contaminated by barium and area of disturbed fauna. This is due to the change from oil-based to water-based drilling fluids following OSPAR Decision 2000/3 on the Use of Organic-Phase Drilling Fluids (OPF) and the Discharge of OPF-contaminated Cuttings and reduced oil and gas activities in the area. The monitoring region B in the Norwegian Sea from 64 – 66 degrees north is a more recently developed area with increasing area contaminated with barium from water based drilling fluids and THC from oil production. Barium content was also measured in both areas in 2005 and 2006, but has not been included in the report by Renaud et al (2008). Measurements are at the same or at a slightly lower level (DNV, 2006b, 2007). The apparent increase in area contaminated with THC at Ekofisk from 2002 to 2005 is due to uncertainties in data used for calculation. DNV (2006b) regards contaminated area calculated for 2005 as reasonably good, while the 2002 area is somewhere between 66 and 165 km^2.

The Norwegian data showed that only a small portion of the Norwegian shelf has been influenced by petroleum exploration and production. The percentage of the shelf that shows evidence of metal contamination and ecological impact remains low, and has decreased in most regions since the first cycle of regional monitoring (Renaud *et al.*, 2008). The total area currently impacted is well below 0.10% of the total area of the Norwegian monitoring regions.



A. Ekofisk



B. Halten Bank

Figure 4.3 a and b: *Area contaminated with total hydrocarbon concentration (THC) and barium and areas with affected fauna. Data from two different Norwegian monitoring regions; the Ekofisk area (Region A) situated in the southern part of the North Sea (OSPAR region II), and the Halten Bank (Region B) situated in the southern part of the Norwegian Sea (OSPAR Region I). Source: Renaud et al., 2008)*

Dutch studies undertaken in the southern North Sea (OSPAR region II) show that discharge of water-based fluids and cuttings had no detectable effect on the benthic community, whereas effects were found out to 250 metres from the discharge point 20 years after discharge of oil-based fluids (OSPAR, 2007b).

Regional monitoring studies have been undertaken by the United Kingdom at the Fladen Ground, East Shetland Basin and the Eastern Irish Sea. Results from the Fladen Ground showed that concentrations of Forties crude oil equivalent, Diesel oil equivalent, total PAH and total n-alkane were all considerably lower than in 1989 with aromatic hydrocarbon concentrations lower than background levels (BERR, 2008). Similar results were obtained from the monitoring undertaken in the East Shetland Basin.

Recent site specific monitoring at a number of single well locations drilled using oil-based fluids in the 1980s indicated low sediment hydrocarbon concentrations beyond 200 metres from the well location with elevated levels nearer to the well. However, the concentrations were considerably lower than in 1987.

Monitoring data from five producing fields have been more variable but have also generally shown reductions in hydrocarbon concentrations since the cessation of oil-based discharges.

Regional scale benthic ecological perturbation attributed to oil industry activities has not been detected on the United Kingdom sector. This is in contrast to previous results from the Norwegian sector (Olsgard and Gray, 1995) where measurable effects on the bottom fauna were shown 2 – 6 km away from platforms after several years.

4.4 Management of old cuttings piles

Monitoring undertaken near cuttings piles historically contaminated with oil-based fluids indicates that concentration and spatial extent of contamination have reduced and leaching rates diminished since the initial discharge. In some cases this has been substantial, with one location in the United Kingdom recording a decrease in the estimated environmental effect footprint from 7.07 km^2 to 0.79 km^2 between 1992 and 2008 (ERT, 2008). The conclusions from mapping of a decommissioned platform in the United Kingdom were that disturbance of the cuttings pile due to decommissioning activities had no major effect on the spatial distribution of cuttings contamination or the biological communities present in the seabed beyond 100 m from the original location of the installation.

Reports from the Netherlands (OSPAR, 2009d) concluded that none of the former oil-based mud fluids (OBM) discharge sites on the Dutch Continental Shelf that exceeded the thresholds for rate of oil loss or persistence (specified in OSPAR Recommendation 2006/5 on possible leakage and areas affected by cuttings piles) and therefore did not require further assessment. A similar Norwegian report (DNV, 2008) stated that it is likely that all the existing cutting piles in the Norwegian sector meet the OSPAR guidance and no further evaluation is necessary. In the United Kingdom that the calculated rate of loss for 168 installations was well below the threshold value and for more than half of them the calculated leakage was less than20 % of the threshold value. The calculated persistence values were also below the OSPAR threshold values (ERT, 2008).

All Contracting Parties concerned have demonstrated that the cuttings piles are below the thresholds put forward in OSPAR Recommendation 2006/5. There is therefore no need for further actions in this regard. Post decommissioning surveys will continue to provide information on this subject.

4.5 Chemical use and discharge

Reliable data on the use and discharge of chemicals are only available for 2003 onwards. Use and discharges of offshore chemicals vary depending upon the level of drilling activity. The amount of chemicals used offshore has increased in the last years to around 900 000 tonnes in 2007. However, there has been an overall reduction in the total discharge of chemicals of about 8% from 274 000 tonnes in 2003 to 253 000 tonnes in 2007 (Figure 4.4). Discharges of substances on the OSPAR List of Chemicals for Priority Action (LCPA) have been reduced by 90% since 2003. This is largely due to the common effort among the Contracting Parties and the industry to substitute these chemicals for less hazardous alternatives.

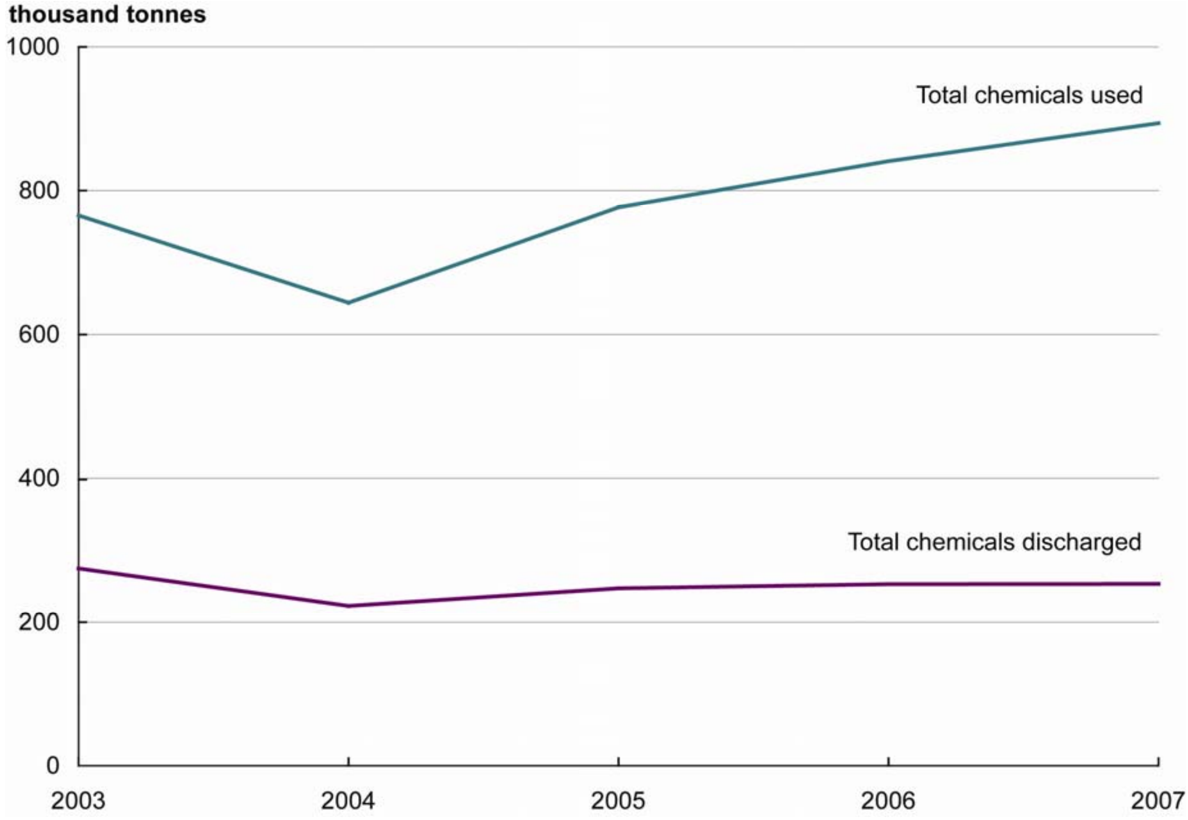


Figure 4.4 *Use and discharge of offshore chemicals in 2003-2007 in thousand tonnes*

In 2007, only 0.8% by weight of the discharged chemicals contained LCPA substances or substances which are candidates for substitution (hazardous chemicals to be substituted by less hazardous substances). The 70 kg of LCPA substances discharged in 2007 was lead used in protective lubricant for pipe joints. Most of substances used and discharged are considered by OSPAR to pose little or no risk to the environment (PLONOR substances). In 2007, almost 87% of the chemicals discharged were PLONOR (Figure 4.5).

Contracting Parties have also achieved a more harmonised approach to management of offshore chemicals and interpretation of the guidance laid down in the HMCS. OSPAR measures such as the harmonised notification format and harmonised pre-screening procedures for offshore chemical have eased the work of both authorities and the industry and have made regulatory decisions related to discharge of offshore chemicals within the OSPAR area more transparent and predictable.

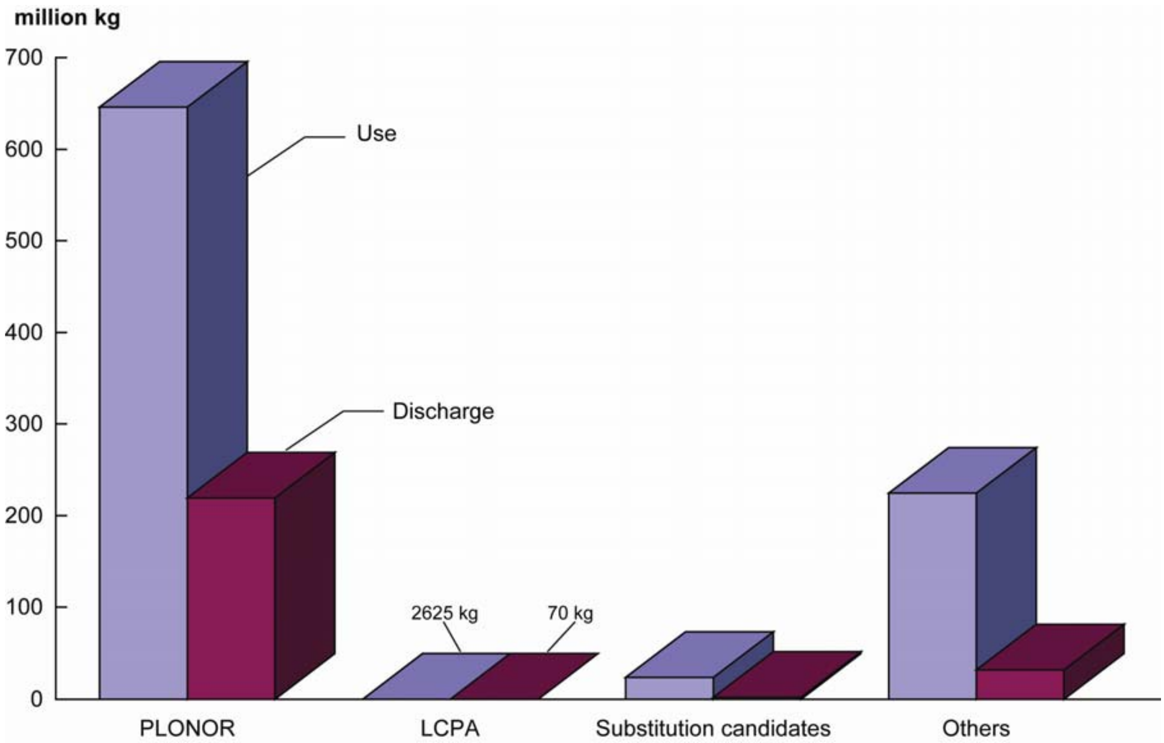


Figure 4.5: *Use and discharge of different categories of offshore chemicals in 2007. LCPA: Substances on the OSPAR List of Chemicals for Priority Action (Agreement 2004-12). PLONOR: Substances used and discharged offshore which are considered to pose little or no risk to the environment (Agreement 2004-10).*

Substitution candidates: Sum of substances reported as: inorganic with LC50 or EC50 less than 1 mg/l; biodegradation less than 20% in OECD 306, Marine BODIS or any other accepted marine protocols or less than 20% during 28 days in freshwater (ready test); meets two of the three OSPAR criteria for biodegradation, bioaccumulation and toxicity (OSPAR Recommendation 2000/4).

4.6 Atmospheric emissions

OSPAR has no own regulation for atmospheric emissions from the oil and gas industry, however, significant reductions have taken place in the volume of volatile organic compounds and sulphur dioxide being emitted. There are no significant trends in the volumes of carbon dioxide, methane and nitrogen oxides being emitted, however, it can be assumed that these will also decrease in the future as the European Union Emissions Trading Scheme and the IPPC Directive become more established.

4.7 Decommissioning

OSPAR Decision 98/3 prohibits dumping, and the leaving wholly or partly in place, of disused offshore installations within the maritime area. It is possible to seek derogation to this decision if a Contracting Party can demonstrate significant reasons why an alternative disposal option is preferable. The majority of installations are removed at the time of decommissioning. A review of experience and technical developments relating to the decommissioning of platforms was undertaken in 2008. The review showed that the number of projects involving concrete structures and substantial steel footings has been very low and there have been no significant developments in the technical capabilities of the industry which would support a reduction in the categories eligible for derogation. OSPAR will undertake a further review of the situation in 2013.

Since the ban on dumping of disused offshore installations came into force in 1999, 122 offshore installations have been brought ashore for disposal. Five permits have been issued for structures to be left in place (four concrete substructures and the footings of one large steel structure). The decommissioning of the Frigg Field is presented in the Annex as a case study on the application of OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations.

There are 59 steel installations with a substructure weighing more than 10 000 tonnes and 22 gravity-based concrete installations for which derogations from the dumping ban may be considered. In the light of experience in decommissioning offshore installations, relevant research and exchange of information, OSPAR aims to ensure derogations from the dumping ban remain exceptional.

5. How does this work affect the overall quality status?

5.1 Impact from offshore oil and gas activities

The exploration for and the development of oil and gas resources within the OSPAR convention area for over thirty years have caused localised impacts on the environment. The following section focuses on those impacts that are considered to have been the most significant.

5.1.1 Sediments

As a result of contamination by OPFs and the settlement of suspended fine cuttings, benthic fauna become stressed. This results in lower diversity and the dominance of tolerant opportunistic species in several square kilometres around the well location. Areas of impact have been detected up to three kilometres away and in rare cases up to six kilometres, from the drilling locations (Olsgard and Gray, 1995). Since the ban on discharges of diesel oil-based drilling fluids and the restriction in discharge of other oil-based drilling fluids, and after the substitution of the most hazardous chemicals with less hazardous substances, the impact has significantly reduced.

It is more than 15 years since the discharge of oil contaminated drill cuttings was prohibited, but cutting piles are still present under some platforms. Studies have shown that the leakage of oil from these cuttings piles is low and their individual footprints are contracting due to natural degradation (see section 4.3 and 4.4).

The discharge of drill cuttings and water-based fluids may cause some smothering in the near vicinity of the well location. The impacts from such discharges are localised and transient, but may be of concern in areas with sensitive benthic fauna, for example corals and sponges.

5.1.2 Physical impacts on the seabed

Contracting Parties do not undertake extensive monitoring programmes to assess the physical impacts of the placement of structures on the seabed. Historical monitoring has demonstrated that the impacts are largely transient, with re-colonisation of disturbed seabed habitats occurring within relatively short timescales.

The creation of hard bottom substrate can, over time, give an opportunity for new benthic species to colonise the former sandy/mudflat areas. Pipelines, platform legs and subsea templates may act as shelter for fish and other mobile marine organisms, and provide a habitat for benthic organisms usually associated with hard substrates.

Physical impacts on the sea bottom will occur in connection with installing pipelines, cables, bottom rigs, templates, skids, and platforms including platform legs and anchoring. Due to the number and length of pipelines placed on or under the seabed the overall physical impact of pipelines is greater than those from the other installations or operations mentioned above. Therefore this section refers mainly to physical effects from pipelines. However, other installations will cause qualitatively similar impacts to those described for pipelines, but at a smaller scale.

Pipelines are either placed on the seabed or buried partly or completely in the sediment. Impacts are caused by the actual placement of the pipelines, particular in areas where the pipelines are to be trenched and buried. Pipelines are buried to ensure that they are not buoyant and they remain in place; this also reduces the potential hazards for fishermen. The vessels deploying pipelines can also impact the seabed if they are using anchors to maintain position. Compared to the long term direct physical impact of the pipeline itself these impacts are usually short term with the recovery of the seabed over time.

The footprint of the pipeline, or the affected zone around it, is dependent on length, diameter, the degree of burial or build up of gravel *etc*. Pipeline burial causes the largest impact during the installation phase because of considerable disturbance of the seabed and mobilisation of sediment. The volume and distance that suspended sediments disperse depends on particle size, weight and current velocity. The area of impact during pipeline burial is considered to be within 10 – 20 m of the line, but once buried, pipelines usually have insignificant impacts. However, once a pipeline is laid there is a risk that upheaval buckling may occur along certain areas of the line. Free-spans may also occur underneath the pipeline when the seabed topography changes due to sediment movement. In these situations it is critical for the integrity of the lines and safety of fishermen to place gravel or concrete mattresses along those parts of the line. In areas of soft sediment this activity introduces a hard substrate into the environment.

Benthic communities will be impacted for a variable period of time. In areas of soft sediments, where most pipelines are trenched and buried, the soft bottom fauna re-colonises within a year or two. In areas of harder substrates the recovery of benthic communities may take longer, up to 10 years in deeper colder water areas. There are few pipelines that are trenched and buried in these areas. In impacted areas there is a gradual change in the species composition of benthic communities until equilibrium is achieved depending on the new local conditions. During the re-establishment of the area it is also possible that specific diversity will increase due to the colonisation of hard structures by previously absent benthic species.

Due to differences in bottom topography, geology, water mass movement and other environmental factors such as sensitive benthic species and habitats (particularly coldwater corals and sponges), the potential problems in introducing these structures will meet different challenges depending on the natural conditions in the different OSPAR Regions.

In recent years the oil industry has begun to decommission redundant installations and pipelines. The removal of the installations and associated infrastructure can cause sediment disturbance and subsequent localised impacts. If there is a cuttings pile at the base of the platform this may be disturbed contaminated cuttings re-suspended. However, evidence indicates that these re-suspended particles do not disperse and settle back in the same area. On occasions it may not be possible to remove the lower parts of a platform, for example concrete substructures and the footings of the largest steel installations; the parts left in place may form artificial reefs and habitats which additional species may colonise.

5.1.3 Impact and effects in the water column

The main impacts affecting the water column arise from the discharges of produced water and accidental spills of oil and chemicals. Assessing the impacts of these discharges on the water column is challenging, but recent research has provided evidence indicating what the impacts may be.

Water column monitoring has been carried out to a limited extent in the OSPAR area to determine the possible effects of discharges of produced water. Water column monitoring in the Netherlands' sector in 1997 has shown an accumulation of the PAH naphthalene in blue mussels up to 1000 m from a platform (Foekema *et al*., 1998).

Water column monitoring started in Norway in 1999. The water column monitoring programme has two parts, both of which make use of biomarkers (Box 2). Part one includes measurements of selected hydrocarbons in commercially important fish species (wild fish) every third year. Sampling is performed in a contaminated and non-contaminated area. The other part studies the fate and effect of produced water discharges and makes use of large cages with blue mussel and cod as test organisms. The cages are deployed in the vicinity of a field. This part is carried out on an annual basis in one region per year.

Box 2

Biomarkers relevant to exposure to produced water

DNA adducts of PAHs: Indicate exposure to PAHs able to affect DNA integrity and therefore potentially cause cancers.

PAH metabolites: Increased levels of PAH metabolites in fish bile indicate increased exposure to PAHs.

Lysosomal stability: Lysosomes are organelles that are important in the defence of cells against foreign bacteria and other wastes. The stability of these structures can be affected by toxins, such as the PAHs found in crude oil. The stability of the lysosomal membrane has been used in ecotoxicological studies to demonstrate the health status of mussels.

EROD (ethoxyresorufin-*O*-deethylase) activity: EROD is one of many proteins involved in metabolising toxic compounds. EROD activity indicates exposure to a wide variety of planar organic substances.

GST (glutathione *S*-transferase) induction: GST is an enzyme involved in the metabolism and elimination of toxic substances from cells. Induction of GST indicates exposure to a range of potentially toxic substances.

Vitellogenin induction: Vitellogenin is a protein present in female fish and in some other female animals. Induction of vitellogenin in males can be used as a molecular marker of exposure to oestrogenic endocrine-disrupting chemicals.

Results show that caged blue mussels (Mytilus edulis) accumulate PAH, but that the levels decrease with increasing distance from the discharge point. Other indicators of exposure also show a gradient with stronger responses in the cages closest to the produced water discharge (Sundt et al., 2008).

During the monitoring in Norwegian waters in 2002 and 2005 wild cod *(Gadus morhua)*, saithe *(Pollachius virens)* and haddock *(Melanogrammus aeglefinus)* were caught and analysed. Di- and poly-aromatic hydrocarbons (NPD/PAH) have been analysed for in muscle of cod and haddock caught in the North Sea at Ling Bank/Egersund bank (reference area), Tampen, Halten Bank and in the Barents Sea (reference area) in the autumn of 2005 and concentrations were found to be below levels of quantification for fish sampled in all regions (Grøsvik *et al.*, 2007; Klungsøyr *et al.,* 2003).

Analyses of alkyl phenols in the livers of cod and haddock and the muscle of herring *(Clupea harengus)* from the Ling Bank/Egersund Bank indicated levels below limits of detection for all stations. The same results where found in earlier investigations *(*Klungsøyr *et al.,* 2003) and support the findings of an assessment that concluded that the risk for estrogenic and reproductive effects in fish after alkyl phenol exposure from produced water discharges was very low (Myhre *et al*., 2004).

Analyses of haddock from the Norwegian Tampen area have shown increased levels of DNA-adducts and differences in cell membrane lipid composition compared to fish from other areas. However, it is not possible to link this with the direct effects of produced water, as haddock is a bottom living species which may feed on contaminated sediments (Grøsvik *et al.*, 2007).

The conclusion of water column monitoring to date is that while some biomarker responses to contaminants in produced water can be observed, it is not clear what these findings mean for the individual fish, the populations or the ecosystems as such. Monitoring indicates no effect or accumulation of substances from produced water in wild fish.

Accidental spills of oil and chemicals may have an impact on the marine life in the upper water column including mammals and seabirds. The level of impact arising from an oil spill is dependent on the location and size of the spill and when it occurs. Ongoing beached bird surveys in OSPAR region II indicate that the majority of oiled birds occur in the southern North Sea where the majority of the fields are gas and therefore unlikely to be the cause of the pollution. here is no evidence that accidental spills of chemicals significantly impact the water column.

Drop out of oil from flaring can occur, particularly when undertaking well clean-up or well testing operations. The majority of well clean-ups and well tests do not have oil drop out and from those that do, the volume of oil discharged into the water column is considered to be negligible. No environmental impacts have been reported from these activities.

Impacts from noise due to offshore oil and gas activities are unavoidable. Seismic surveys are required for exploration and to a lesser extent the production phase. All construction work when developing an oilfield creates noise of some kind. Potential effects from noise vary depending on the sensitivity of the receptor and its proximity to the sound source. There is potential for an increase in mortality of juvenile stages of fish, permanent or temporary hearing impairment and the displacement of fish and marine mammals from their normal range (OSPAR, 2009a).

The most significant source of noise is from seismic surveys. Evidence indicates that for marine mammals there may be some behavioural changes in areas where seismic surveys are being undertaken with reduced vocalisation and some evidence of avoidance behaviour. Temporary threshold shifts in hearing can occur if they are within close proximity of sound source. Impacts on fish from seismic surveys have been shown to occur with an increase in fish mortality less than 5 metres from the sound source. Temporary threshold shifts and behavioural responses have also been reported. Evidence from North Sea indicates potentially large scale avoidance of areas where seismic surveys are being undertaken with fish either moving into deeper water or avoiding the area altogether. Experiments undertaken in the North Sea on sandeels indicated relatively minor responses from seismic surveys with no increases in mortality.

5.1.4 Other impacts

Lights and flares on oil and gas installations are known to attract birds and these might cause some mortality in migratory species. The level of impact depends on the location of the platform, the time of year and the prevailing weather conditions at the time with birds being most frequently attracted during the autumn migration and periods of poor weather. Research is currently underway to determine whether platform lighting results in a significant negative impact on bird populations (Poot *et al*., 2008).

5.2 Effectiveness of OSPAR measures

Studies have been undertaken by OSPAR Contracting Parties looking at a wide range of potential impacts including cuttings piles, produced water, drilling fluids and chemicals. The result of all this has been a measurable decrease in emissions and discharges. Impacts that were once widespread for example from the discharge of oil-based fluids, have now ceased and the level of contamination has decreased over most of the OSPAR region. Where potential impacts may still occur, these have been reduced, for example over a 15% decrease in the quantity of oil discharged into the sea in produced water.

Evidence from monitoring and reporting indicates that the overall effect of these OSPAR measures and their implementation by Contracting Parties has been to significantly improve the overall quality status of the OSPAR maritime area as a whole, particularly in areas of Regions II and III where there are high levels of oil and gas activity. The conclusion so far from water column monitoring is that there can be biomarker responses, indicating exposure to produced water, but whether this exposure causes any ecological effects is yet to be determined. There are no results from monitoring so far that indicate any effects from contamination from produced water in wild fish.

6. Conclusions and what do we do next

Since the last QSR in 2000 there have been substantial changes in the way the offshore oil and gas industry operates in the OSPAR region as a result of the implementation of OSPAR measures by Contracting Parties and industry. The consequences of which has been a measurable improvement in the marine environment previously impacted by industry. However, there are areas where it may be possible to further reduce potential impacts. The text below highlights some of these areas:

6.1 The measures taken by OSPAR have been effective in reducing discharges of organic-phase drilling fluids, oil in produced water and chemicals.

The measures have lead to the following:

- Discharges of drill cuttings contaminated with oil and organic-phase fluids have ceased.
- Areas affected by contaminated drill cuttings and effects on sediment dwelling fauna have been greatly reduced, and oil leaching rates from cuttings piles have diminished. The effect has mainly been shown in Region II, which has had the highest levels of oil and gas exploration, appraisal and exploitation.
- Disused offshore installations are not dumped in the OSPAR Maritime Area, but some (sub-) structures are left in place with special permits. This is most relevant for Region II where activity has been most intensive and has taken place over a long time span, but now has partially depleted reservoirs and old infrastructure.
- For the OSPAR area as a whole, discharges of oil with produced water have been reduced by 21% from 2000 – 2006.
- The discharge of chemicals for priority action has been reduced by 90% from 2003 to 2007, and the discharge of chemicals to be substituted has been reduced by 48%. Also, the measures have lead to progress towards a harmonised approach to management of offshore chemicals.

6.2 The further reduction of discharges of oil and chemicals is challenging

- The reduction of oil discharges was set against a trend of increasing produced water generation due to maturing oil reservoirs, particularly in Region II.
- Hydrocarbon production is at different stages and intensities in different regions; for instance in Region I production is still increasing.
- Injection of produced water has proven to be technically very challenging for some installations mainly because of reservoir properties.
- Substitution of certain chemicals has proven to be technically very challenging.
- Working with the industry has been an asset in identifying issues to be addressed and finding solutions for discharges of produced water, the use and discharge of chemicals, and putting in place environmental management systems by operators.

6.3 Priorities for action in the future

Work will continue to move towards the target of the cessation of discharges, emissions and losses of hazardous substances and to achieve a reduction of oil in produced water discharged into the sea to a level which will adequately ensure that each of those discharges will present no harm to the marine environment by the year 2020. Much has been done to reach the 15% reduction of discharges of dispersed oil. Rather than focusing solely on oil in produced water, there is a need to move towards a more holistic, risk based approach to management of produced water. The risk based approach will cover other substances in produced water than oil, and could serve as a field specific tool to identify whether or not further action is required with regard to produced water discharges.

The action for the future was discussed by OSPAR's Offshore Industry Committee in 2009, who agreed that the following items should be priorities:

- Participate in the development of programmes and measures to help attain good environmental status as required by the EU Marine Strategy Framework Directive (2008/56/EC).

- Bring HMCS in line with the REACH Regulation.
- Monitor the development of Contracting Parties’ carbon capture and storage activities to ensure that measures in place are appropriate.
- Investigate whether there are specific issues relating to aging installations and infrastructure and, if required, to develop appropriate measures in light of possible extension of field life. In Region II, numerous installations will have to be decommissioned in the coming years as more and more oil and gas fields become depleted and commercially non-viable.
- Consider whether the current OSPAR measures are suitable for oil and gas activities in the Arctic part of Region I. As the resources in the central North Sea are depleting, exploration is moving into deeper areas and up into the Arctic. Operations in these areas are environmentally challenging due to harsh climatic conditions and sensitive ecosystems. Therefore, there is a need for higher precaution and new technologies must be developed.

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8. Glossary and abbreviations

Base fluid	The water immiscible fluid which forms the major part of the continuous phase of the OPF
Drilling fluid	Base fluid together with those additional chemicals which constitute the drilling system
HMCS	Harmonised mandatory control system for the use and reduction of discharge of offshore chemicals
JAMP	Joint Assessment and Monitoring Programme
LCPA	List of chemicals for priority action
Oil-based fluids (OBF)	Low aromatic and paraffinic oils and those mineral oil-based fluids that are neither synthetic fluids nor fluids of a class whose use is otherwise prohibited
Organic Phase Fluids (OPF)	An organic-phase drilling fluid, which is an emulsion of water and other additives in which the continuous phase is a water-immiscible organic fluid of animal, vegetable or mineral origin
PARCOM	Paris Commission
Polycyclic Aromatic Hydrocarbons (PAHs),	Polycyclic Aromatic Hydrocarbon
Synthetic fluid	Highly refined mineral oil-based fluids and fluids derived from vegetable and animal sources
Cuttings	Solid material removed from drilled rock together with any solids and liquids derived from any adherent drilling fluids
THC	Total hydrocarbon concentrations
Whole OPF	OPF not adhering to or mixed with cuttings

Annex – Case studies

Ekofisk - monitoring with a long history

(Source: Renaud *et al.,* 2008)

Ekofisk in the North Sea was the first production field on the Norwegian shelf, starting up in 1971, and thus has a long history that spans a variety of operational practices. The duration and nature of activity at Ekofisk suggest that the surrounding environment has been considerably affected by exploration and production activities. It may also be one of the sites where long-term ecological changes may be observed, including possible recovery following the switch from the discharge of oil-based to water-based fluids. The data presented here are from the Centre and 2/4 B&K installations at Ekofisk.

Monitoring of different parameters in the bottom sediments has been done at Ekofisk for more than 20 years. Results from selection of these are shown beneath for the near fields stations and the reference stations. Sediment grain size (fine sediments/silt and clay fraction) by monitoring % of pelite and the total content of organic matter (TOM) gives a background on the sediment characteristics and explains to a certain degree the faunal component composition. Barium (Ba) concentrations is a useful tracer of weight material (barite) dispersion and transport of discharges related to drilling activities and the use of Total Hydrocarbon Content (THC) gives an indication on the production/spill of oil at the installations

There has been little evidence of significant change in either pelite or total organic matter at Ekofisk from 1990 to present (Figure 1). Ekofisk is characterized by shallow (under 100 m) water and sandy sediment with low pelite values. Pelite values were less than 8% for all but one sampling, and were higher at field stations compared to reference stations at nearly all sampling dates. TOM values were virtually identical between the two types of station at all sampling dates.

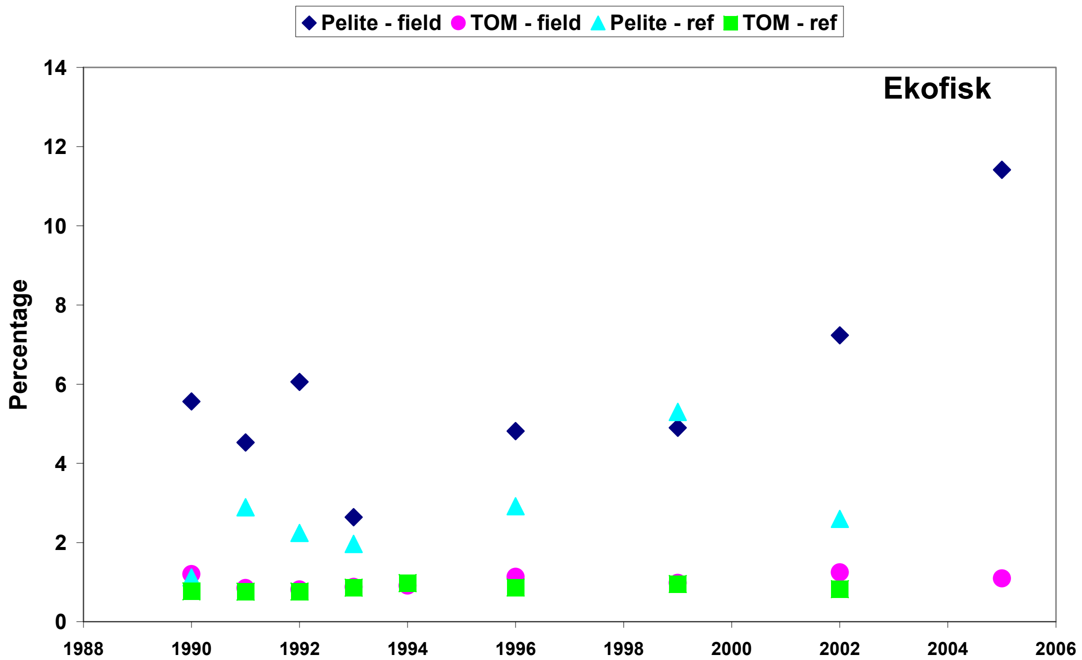


Figure 1: *Annual mean grain size (% pelite) and total organic matter (% TOM) 1990 – 2005*

Total hydrocarbon (THC) concentration was high at Ekofisk during the early 1990s (mean values up to 234 ppm, with a maximum value of over 3000 ppm at one station 100 m from the installation in 1992), but declined rapidly after the ban on discharges of OBM effective from 1993 (Figure 2). From 1994 to present, the average concentration has been above 50 ppm (the accepted Predicted No-Effects Concentration, PNEC; UKOOA, 2002, DNV, 2004) only once, in 2002. Barium concentrations showed no obvious trend at

Ekofisk during the time period, with an average between 1000 and 3500 ppm at all field sites (Figure 2). It is important to consider that all of these values are means and include stations as close as 250 m and as far away as 4000 m.

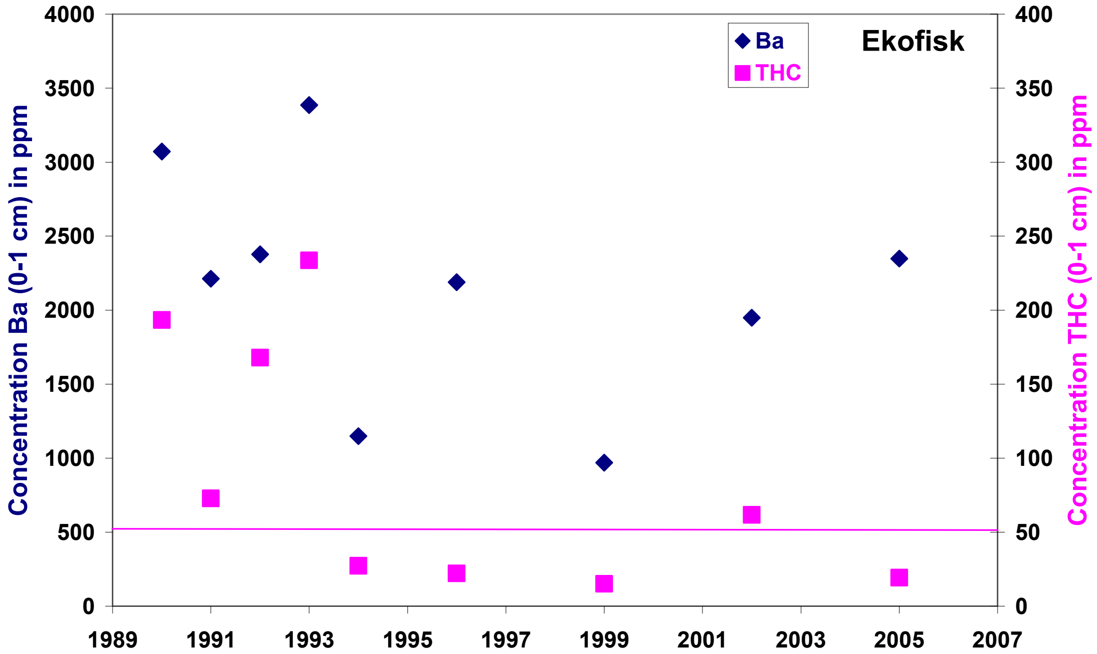


Figure 2: *Annual mean values in concentrations of barium (Ba) and total organic hydrocarbon (THC) 1990 – 2005. The red line indicates the PNEC level of 50 ppm for THC.*

Multidimentional scaling plots (MDS) of ecological data can/might be used to evaluate recovery in faunal communities due to changes in discharges or alternation of grain size. Here the MDS plot of ecological data indicate that the faunal community varies more over time than it does with distance from the installation. In addition, there is a sharp division between stations sampled from 1990 – 1993 and those from 1996 to present (Figure 3). This may be the effect of the cessation of oil-based fluid discharges. How quickly this effect occurred is uncertain, as 1996 was the first year such data were collected following the ban. Finally, most reference stations appear to be more similar to each other than to most of the field stations as shown in Figure 3.

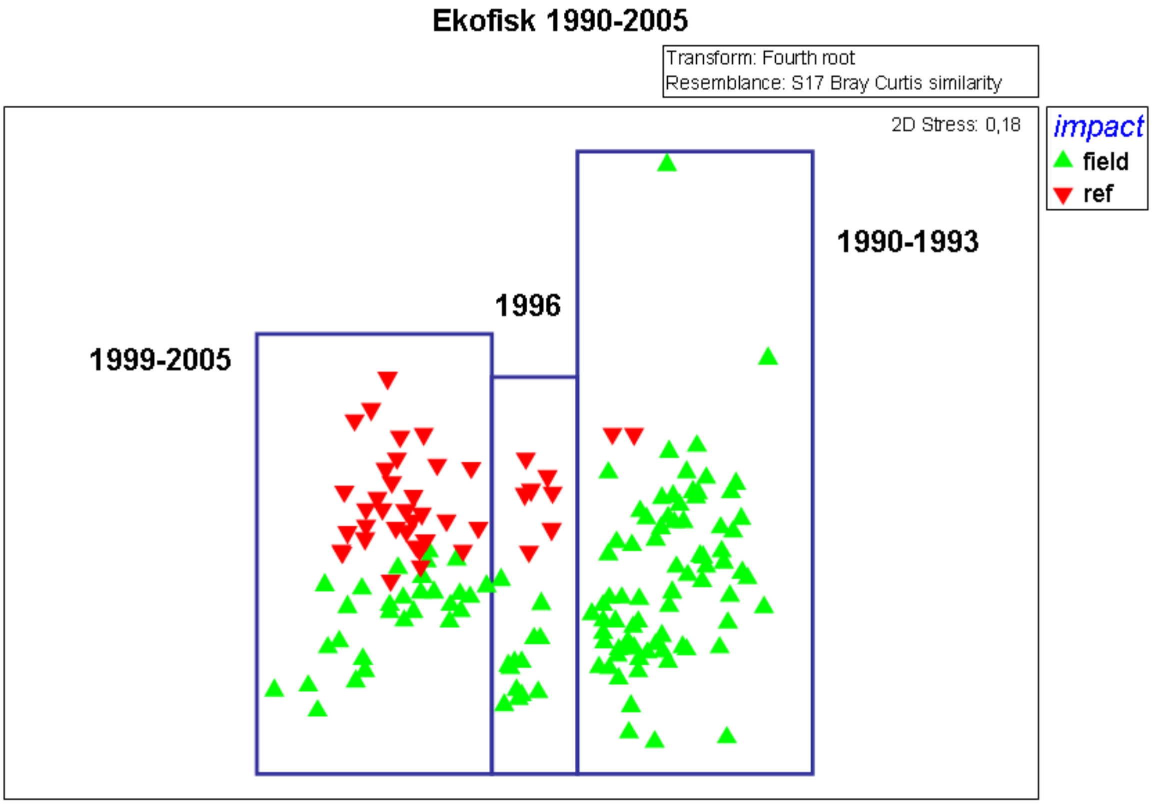
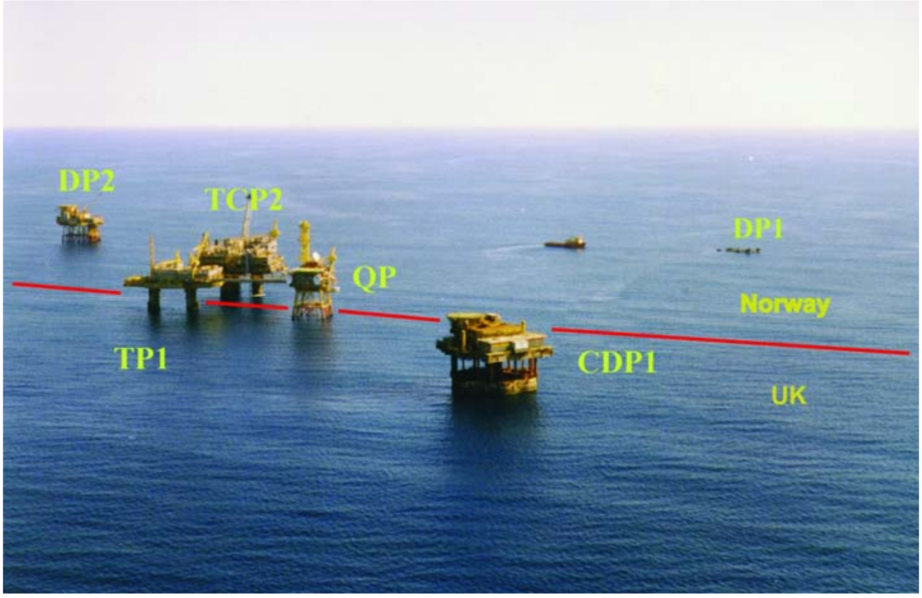


Figure 3: *MDS (multidimensional scaling) plots of faunal communities from field and reference stations. Boxes indicate sample year.*

Frigg Field - Decommissioning

Frigg is a trans-boundary field spanning the median line between United Kingdom and Norwegian continental shelves. The field was, however, developed and operated as a single unit, reflecting the provisions of the Frigg Treaty 1976, signed by the United Kingdom and Norwegian governments. Three Frigg installations were located in United Kingdom waters, two having concrete substructures. Another three installations, one with a concrete substructure, were located in Norwegian waters. The photo shows the location of the installations (source: Total, Norway). Gas production commenced in 1977 and ceased in 2004.



Separate United Kingdom and Norwegian government approval was required for the decommissioning of Frigg facilities in their respective waters. However, the requirements of OSPAR Decision 98/3 on the disposal of disused offshore installations applied to all the Frigg installations. Following discussions between both national authorities and the operator (Total E&P Norge), all parties co-operated to adopt a common approach to decommissioning the United Kingdom and Norwegian facilities. A single Cessation Plan, incorporating a comprehensive environmental assessment, was produced encompassing the complete field whilst having regard to the particular regulatory requirements of each country. This was submitted to both authorities for review and approval with respect to the facilities in their jurisdiction.

The Cessation Plan recommended the concrete substructures in United Kingdom and Norwegian waters remain in-situ. Derogation from the OSPAR 98/3 requirement of total removal to shore would therefore require two permits. In support of the derogation application a single comparative assessment, in accordance with Annex 2 of the Decision, was submitted to both authorities. The United Kingdom and Norwegian authorities consulted the other OSPAR Contracting Parties simultaneously. Close liaison led to both informing the OSPAR Executive of the potential derogation at the same time, thus a simultaneous consultation period ensued. Ongoing co-operation enabled a consistent approach in the approval of the Cessation Plan and the permit conditions attached to the derogations. OSPAR thus fostered a collaborative approach to decommissioning of installations.

The Frigg concrete substructures were allowed to remain in situ, while the external steel structures have been removed and disposed on land. This was considered the most environmentally friendly option, taking into account considerations such as CO_2 emissions involved in the different disposal alternatives. These ranged from 265 000 tonnes to refloat and dispose of the concrete onshore, to 14 000 tonnes for leaving the structures in place. The permit conditions also required the operator must to recycle as much of the equipment and material as practicable, applying most appropriate techniques and best environmental practice.

OSPAR COMMISSION

New Court
48 Carey Street
London WC2A 2JQ
United Kingdom

t: +44 (0)20 7430 5200
f: +44 (0)20 7430 5225
e: secretariat@ospar.org
www.ospar.org

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